Australian ACACIAS

The potential to combat child malnutrition, build agricultural resilience and support adaptation to climate change in semi-arid Africa.

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Executive summary

Niger, along with other Sahelian countries, faces growing food insecurity due to a combination of rapid population growth, resource degradation and climate change. Traditional agricultural systems, based primarily on pearl millet, are failing to produce to expectation as often as two years in three, with near total crop failures that lead to famine occurring approximately every five years.

The regular recurrence of production shocks has reduced the viability of family farms and the resilience of small farmers by eroding both financial and natural capital. The result is a rural population that lives ever closer to the edge, for whom even small food price rises or production losses can be catastrophic. The impact of this food insecurity falls disproportionately upon the young, and levels of child malnutrition in Niger are at a level that has been described as a 'permanent emergency'.

The plight of the young is exacerbated by a set of customary child care practices that deepens vulnerability to malnutrition. Foremost of these is the practice of weaning infants early and precipitously, to a diet comprised almost exclusively of millet prepared as a porridge known as 'kunu'. A diet of millet provides insufficient energy and protein and is deficient in many micro-nutrients, especially Vitamin A, zinc and iron. An effective treatment for clinical malnutrition has been found in the Ready-to-Use Therapeutic Food (RUTF) 'Plumpy'nut' that is being enthusiastically distributed by agencies such as Médecins Sans Frontières. This approach is limited in vision, however. What Plumpy'nut does not do is encourage any community ownership of the food systems that underpin community wellbeing, build any resilience into agricultural systems, allow any adaptation to the changing climate, or deliver any long-lasting understanding of how malnutrition might be avoided in the future. A much more integrated and empowering solution needs to be found if child malnutrition is to be eradicated over the longer term.

A suite of edible seeded Australian acacia trees (A. colei, A. torulosa, A. tumida and A. elacantha) has the potential to deliver a significant range of benefits for farmers and their families in semi-arid regions. The seed of the Australian acacias is high in protein and other nutrients, has been demonstrated to be a safe food, and is an excellent nutritional complement to pearl millet, the regional cereal staple. Two decades of research and development has produced superior provenances, and yielded compelling evidence that the Australian acacias are also able to contribute valuable fuelwood and building materials, reduce destructive wind speeds, fix nitrogen and produce copious organic material, all of which add to rural livelihood resilience. The wood of Australian acacias may have further uses in the production of renewable energy, sequestration of carbon in soils and participation in global carbon markets. The widespread planting of Australian Acacias can thus be seen as an important step in rural communities adapting to climate change.

The seed of the Australian acacias has strong potential to improve child nutrition in Niger and other semi-arid regions. Acacia seed can be added to traditional cereal foods that are given to infants at weaning. The addition of acacia seed (and Moringa leaf) to cereal foods (such as kunu) can increase the availability of energy, quality protein and many micro-nutrients to children. Therefore, the use of acacia in complementary (weaning) food could make a dramatic difference to the quality and availability of food for infants and children who would otherwise be vulnerable to malnutrition.

The use of acacia in children's foods should be encouraged at three levels:

1: Village level, wherein the concept and recipe for an acacia/moringa kunu is promoted as part of a package that provides nutritional education, encourages the planting of acacia and moringa trees, and includes measures to ensure that acacia seed is available to those who wish to buy it. This approach would require a significant education effort, but promises the greatest impact in reducing child malnutrition. It is envisaged that acacia seed will ultimately be adopted into family diets as a normal part of the household economy.

2: Urban/regional level, where supporting and replicating micro-enterprises will do much to alleviate malnutrition in urban areas. In this approach it is envisaged that some of the product may be purchased for distribution by funded organisations, whilst the product may also be purchased by families for use in the home.

3: Institutional level, wherein the further refinement, validation and large scale production of highly nutritious acacia kunu, comprised mainly from local ingredients, will allow nutritional support to vulnerable families during dry years. In this approach, it is envisaged that the costs will be borne by organisations that are involved in famine relief. By creating a nutritional support product that is almost entirely grown in the semi-arid tropics, 'food aid', that has so often been as destructive as it has been necessary, can become a transformative force that actively builds resilience and prosperity in rural communities.

In order to implement these recommendations, a significant improvement in the availability of acacia seed will be necessary. Widespread planting of trees will be important. The best approach in this regard is family farms, since this places the seed where it can be accessed by families, but options such as plantation production on degraded lands should also be actively pursued. Efforts should be made to ensure that acacia seed is available in rural villages: by encouraging plantings, by stocking acacia seed in community cereal banks and by encouraging and facilitating petty traders to keep a supply on hand for sale.

The potential of Australian acacias is not limited to the Sahel. The existence of many millions of Acacia saligna in the arid mountains of Tigrai, Ethiopia offers the possibility that similar programs could be developed in that region as are recommended for the Sahel.

Steps to implementation are included in Tables 8 and 9, on pages 89-93 of this report.

> "The seed of the Australian acacias has strong potential to improve child nutrition in Niger and other semi-arid regions."

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List of abbreviations

CDM	Clean Development Mechanism
CSB++	Corn-Soy Blend with nutritional fortifications (a product widely used in emergency food distributions)
CSIRO	Commonwealth Scientific and Industrial Research Organisation
FAO	Food and Agriculture Organization of the United Nations
FEWSNET	Famine Early Warning System (a service of USAID)
FMAFS	Farmer Managed Agroforestry System (developed by SIM)
FMNR	Farmer Managed Natural Regeneration
HIV	Human Immunodeficiency Virus
ICRAF	International Centre for Research in Agroforestry, now called World Agroforestry Centre.
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
INRAN	Institut Nationale de Recherche Agronomique du Niger
IRIN	Integrated Regional Information Networks: Humanitarian news and analysis service from the UN Office for the Coordination of Humanitarian Affairs
MSF	Médecins Sans Frontières
OCHA	Office for the Coordination of Humanitarian Affairs
PAM	WFP Programme Alimentaire Mondial
RDI	Recommended Daily Intake
SAT	Semi Arid Tropics
SEF	Sahelian Eco-Farm (developed by ICRISAT)
SIM	Serving in Mission (formerly the Sudan Interior Mission)
SIMA	System Informations Marché Agricole (Niger Government agricultural markets information service)
TARI	Tigrai Agricultural Research Institute
UNDP	United Nations Development Programme
UNHCR	United Nations High Commissioner for Refugees
USAID	United States Agency for International Development
WFP	World Food Programme, United Nations
WHO	World Health Organization
WVA	World Vision Australia
WVE	World Vision Ethiopia
WVN	World Vision Niger

Introduction

Niger is a country that gives us glimpses of one possible future in arid and semi-arid landscapes. It is bleak. Niger is not just a desperately poor country (ranked at 182 out of 182 in the UNDP's 2009 Human Development Report); it is a country where the limits of human population expansion and environmental degradation are becoming starkly evident. Mortimore comments of life in the African drylands that: "…poor people manage their livelihoods and natural resources in conditions of great difficulty… [where] nature's greatest constraints (low productivity and high variability) have to be managed" (2003; 505). Despite there being considerable optimism amongst many scholars (Adams and Mortimore, 1997; Mortimore et al., 2008; Mortimore and Harris, 2005; Mortimore, 2003) concerning increases in agricultural production and apparently improving soil and range condition, these promising developments have yet to manifest significantly in human wellbeing. For many Nigeriens, the margins have diminished to the point that the balance seems to have shifted between what is normal and what is an emergency (Baro and Deubel, 2006). In Niger, acute child malnutrition rates are 'normal' even as they approach, and periodically exceed, the World Health Organization's threshold for intervention (10-14 percent) (WHO/UNHCR, 2009). Staple crops are failing two years in three due to an increasingly erratic climate and dwindling soil fertility, whilst in some areas, around fifty percent of 'arable' land is so degraded it cannot provide more than the most rudimentary rainy season grazing (Rinaudo and Yaou, 2009).

For countries such as Niger, the introduction of new varieties of crop or improved farming techniques have been central to the agricultural development agenda for decades, and continue to yield marginal improvements. There is a simple underlying equation, however: with such a variable climate and such depleted soils, poor people cannot be sustained indefinitely through marginal annual agriculture – and less so with the current population doubling time of twenty-one years. What is required is a fundamental shift in the productive livelihoods of Niger, or the country will be sealed as a perpetual client of international food and development assistance (Rinaudo and Yaou, 2009).

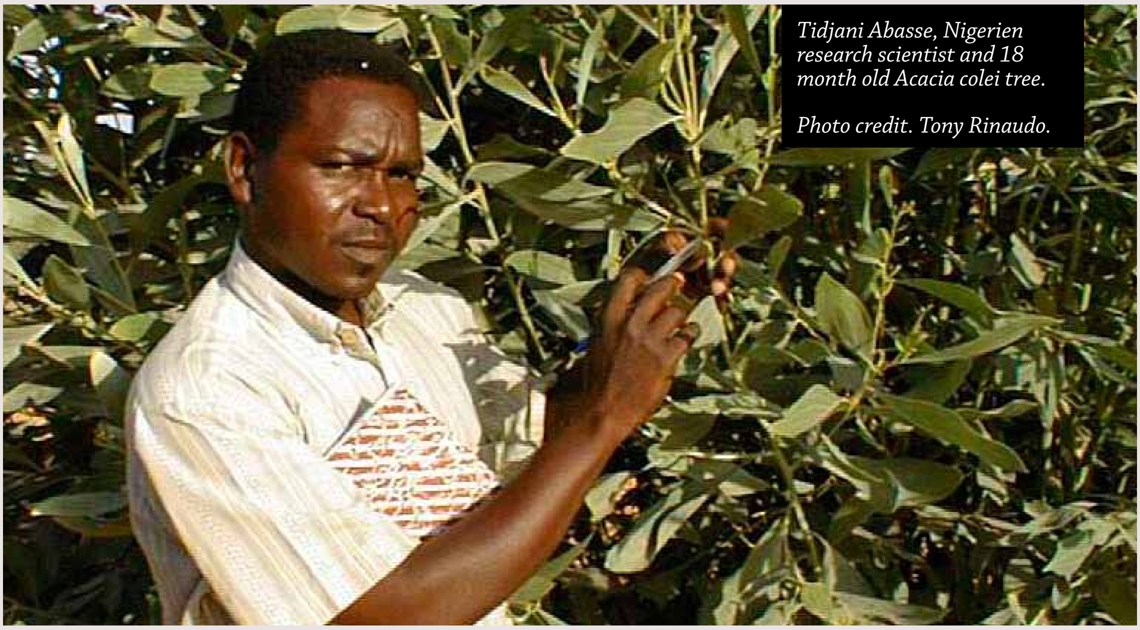
> "Food availability is more important than knowledge and… the reverse is cruel"
>
> (PALMER, 2009)

Research rationale

This research grew out of a conviction that a suite of edible seeded acacia trees from the semi-arid tropics of Australia could and should underpin the transition of Sahelian agriculture, from a highly vulnerable annual system to a more resilient system dominated by perennials. The utility of perennials in dryland agriculture has been well described by Sanchez et al,(1997) who point to the ability of trees to access deeper soil layers, reduce wind erosion and effectively utilise scattered and occasional rainfall events (see also Sholto-Douglas et al., 1984, Garrity, 1994). Though the Australian Acacias currently in use will fail to produce seed in some areas in the drier years (when all other known crops will also fail), they are a fail-safe crop in the sense that they are highly drought tolerant, and will grow and produce wood even in periods of severe moisture deficit. The standing tree, moreover, can be thought of as 'standing capital', with the wood, fruit or fodder able to be harvested for sale in economic extremity.

The utility and potential of Australian Acacias in the Sahel has been demonstrated by several researchers over the past two decades: (Rinaudo et al., 2002, Thompson et al., 1996, Cunningham and Abasse, 2005, Rinaudo and Cunningham, 2007, Midgley and Turnbull, 2003, Harwood et al., 1999, Harwood, 1994, Cunningham et al., 2008), and I contend that there is currently enough knowledge to warrant a widespread and rapid expansion of Acacia plantings in the Sahel. Notwithstanding that there is much work yet to be done in the refinement of agronomic systems and in species and provenance selection and trials for more arid conditions; this need for further work does not diminish the value of what can be achieved with the knowledge we currently hold. As one researcher has pointed out, the current limitation on the expansion of acacia plantings is not technical, but relates to the lack of a functioning market for the seed (Rowlands, 2010). The question is no longer if such plantings should occur, but how they may be achieved and sustained at the scale required to generate a region-wide transformation.

This research was originally intended to explore the potential of the Acacia to address food security at an institutional level. Time in the field quickly showed the opportunity, and the need to take a more integrated approach, so as to explore the potential of acacias to generate benefits to households that encompass nutrition, household income and agricultural resilience, within the context of gender issues, vulnerability and a changing climate.



Tidjani Abasse, Nigerien research scientist and 18 month old Acacia colei tree.

Photo credit. Tony Rinaudo.

Why focus on weaning foods?

When I began work in Maradi, Niger in September 2009, I set out to consider the feasibility of using Acacia seed as a protein and carbohydrate source in an emergency ration that could be stockpiled and deployed during humanitarian emergencies. Whilst this objective remains an important thread in my work, after a brief time in the field it became apparent that a broader consideration of the potential of Australian Acacias to support day to day nutrition, livelihoods and food security would make a more appropriate study. This change stemmed from my realisation of the real depth and pervasiveness of food insecurity and child malnutrition in Niger, and of the further realisation that some relatively small, local level interventions could make a dramatic difference to the nutritional status of a great many children. Wide reading and discussions with health professionals on the causes of child malnutrition pointed to an urgent need to focus on a ‘complementary’ or ‘weaning’ food (Palmer, 2009).

I was greatly surprised to discover that the idea of improving child nutrition through the use of Acacia seed was not new: that a small group of local innovators had been making and distributing baby foods comprising a pearl millet/acacia blend in a Hausa village since 1998. What a gift to find an indigenous initiative on which to build a practically-oriented research project! The way forward became clear: I offered to work with this group, to ‘add some science’ to their efforts, and to help them to refine their product and maximise its nutritional content. The group brought with them a detailed knowledge of crops and agricultural systems, as well as a nuanced (indeed, firsthand) understanding of the local child-rearing practices and food preferences. I brought my knowledge of how best to use Acacia seed, and a nutritional database and basic linear programming capacity that enabled me to assess various recipes for their nutritional content. Together, over several weeks we mixed, cooked and tasted our way to a porridge (‘kunu’) mix. The mix would greatly improve the nutrition of children in the 6-12 months age group during and following weaning, was greatly enjoyed by all who tasted it, and could be produced in remote villages from readily available ingredients – so long as Acacia seed is available, of course. This led to the next set of important considerations: How available is Acacia seed? How can it be made more available? How can the overall production of Acacia seed be boosted to a level that can meet the food security promise these species undoubtedly hold?

Finally, I wanted to return to the original concept of a large scale emergency or supplementary food product, based on Acacia seed and other common Sahelian food crops, that could be distributed to support vulnerable families. With a small amount of supplementation on certain micro-nutrients, the porridge mix my team developed could be made into a product that would meet international standards. The main challenge, again, was how to build up acacia seed production to the level required to achieve the necessary production efficiencies within a reasonable timeframe. That is, to at least 25 tonnes of seed per annum, above domestic consumption needs; perhaps a more difficult task than it sounds, since the popularity of Acacia seed means that domestic consumption is likely to grow very rapidly alongside production.

Niger: a social and agricultural background

Around 70 percent of Niger's population is rural, and virtually all of this population is dependent upon either farming or pastoralism for their livelihoods. Where these modes of production fail, as they so often do, the usual recourse is seasonal labour migration (typically able-bodied men) or dependence on food aid (typically women, children and the elderly).

This research was built around the assumption that the viability of rural livelihoods is a critical underpinning for both local and regional food security in Africa. Rural poverty in Niger is complex, but it seems safe to point to two important contributing factors: The first of these is climatic, with farmers and pastoralists being hit by production shocks – typically drought – about every five years for at least the past three decades. Whilst any single drought may be negotiated with minimal hardship through the sale of assets, switching of livelihoods to wild resources or labour migration, the impact of successive droughts is progressively more debilitating. Capital is exhausted, soil lost and natural resource safety nets depleted, often beyond repair (Leisinger et al., 1995). Of particular concern is the changing climate of the past several decades. The Sahel suffered a severe drop in rainfall of 20-40 percent between the middle and the latter part of the twentieth century, "representing the largest and most sustained rainfall shift of any contemporary region on Earth" (Mahé and Paturel, 2009, Maranz, 2009).

More recently, over the past decade, another very disturbing trend has been observed by farmers as far apart as Maradi in Niger and Tigrai in Ethiopia: Whereas in the past, the rainy season has been relatively predictable in timing and precipitation patterns, there is now a sense of unpredictability, with the season often beginning late and ending early or following a start-stop pattern, with long dry spells between rains that cause annual crops to dry out and fail. In the map below, 'transition zones' with high innate variability are represented by the classifications of semi-desert, steppe, savanna grassland and deciduous forest. It is these zones where the effects of climate change are already being strongly felt, and where these effects are predicted to be greatest.

The second factor contributing to poverty is the position of the rural poor in relation to the market. The production of cereal for family consumption continues to be something of a cultural ideal for many rural Hausa, though a strong market oriented agriculture has also been evident in Niger for many decades (van Duivenbooden et al., 2002). The reality of a pervasive and unavoidable cash economy has progressively undermined this subsistence orientation over the past three to four decades and farmers have been forced to engage with markets wherein they have little power.

Population growth and a changing climate mean that few farming households are able to produce sufficient food to provide for their own needs. Thus food must be bought in, and along with the many other pressing needs (such as clinic visits, livestock vaccinations, school fees, religious obligations, loan repayments, etc), the need for cash is overwhelming. Yet farmers have few means by which to obtain cash: local wage labour opportunities are very limited, and many are forced to sell a significant portion of their staple crop at harvest (when prices are lowest) in order to meet these basic cash needs, even in the knowledge that this will assuredly lead to a grain shortage later in the season.

Cash cropping of peanut, tigernut , roselle and cowpea can alleviate the cash shortage somewhat, however the most widespread solution has become ‘the exodus’: labour migration to the farms, mines and factories of Nigeria and Cote d’Ivoire. There is little doubt that most of the men who make this migration would rather stay home. The life of a migrant is dangerous and hard and one is separated from one’s family for many months at a time. From a public health point of view the ‘exodus’ is a major risk factor for the spread of HIV into Niger’s rural communities.

Another assumption underlying this research is that the nutritional strengths and weaknesses of a cash poor rural society are strongly co-related to the range and appropriateness of species employed in local agriculture (or that are otherwise harvested and used), as well as to the social conditions under which that agriculture is organised (c.f. Apodaca, 2008, Frison et al., 2006, Keatinge and Easdown, 2009). A lack of crop diversity creates vulnerability to external factors such as drought, pests or disease, that can reduce or destroy an entire community’s annual production (Thrupp, 2000). A limited crop repertoire also limits the food options that are available to poor people, making it harder (though not necessarily impossible) to aggregate all the nutrients necessary to a healthy life, a fact that is reflected in the use of ‘Dietary Diversity Scores’ as a quick and efficient means of estimating the likely incidence of micro-nutrient malnutrition (Steyn et al., 2006, Allen, 2003, Arimond and Ruel, 2004).

In the case of the Hausa, the agriculture and indeed the society is dominated by pearl millet (Bivins, 2007; 53); see also Rinaudo (2002). Pearl millet is a rain-fed crop that is grown virtually everywhere in the country where the average rainfall exceeds 400mm/annum. In 1990, Niger produced 1 133,000 tonnes of pearl millet on 3 100,000 hectares of land (FAO, 1995). As a further measure of the importance of cereal crops, in the period 1987-89, cereal sources (principally pearl millet) contributed 93.7 percent of energy, and 83.1 percent of protein to the Nigerien diet (FAO, 1995).

Allinne et al. (2008) estimated that pearl millet crops occupied almost 65 percent of Niger’s farmland in 2007, and note that “...the farming system is mainly traditional and pearl millet is mainly grown for home consumption. Water supplies to... “Pearl millet fields are subject to severe ecological constraints, notably strong annual, inter-annual and geographical variations in rainfall. Over the past fifty years, the cultivated area of... pearl millet has increased five-fold, but the yield per hectare has decreased” (2008;168).

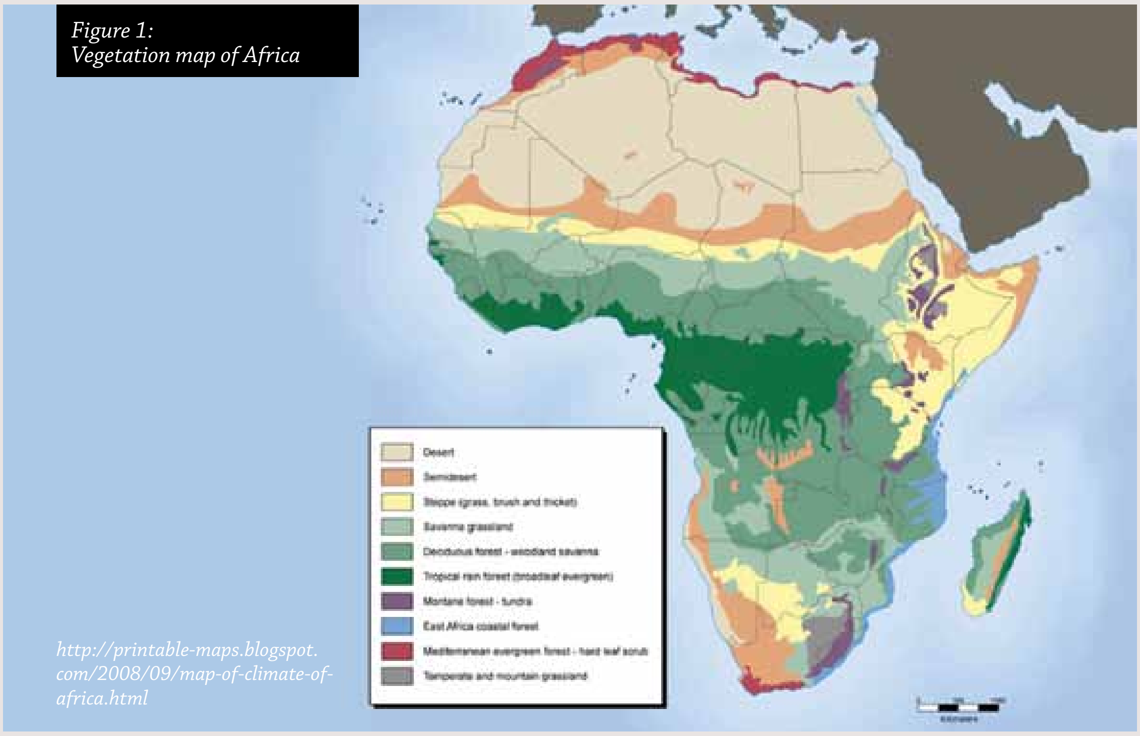


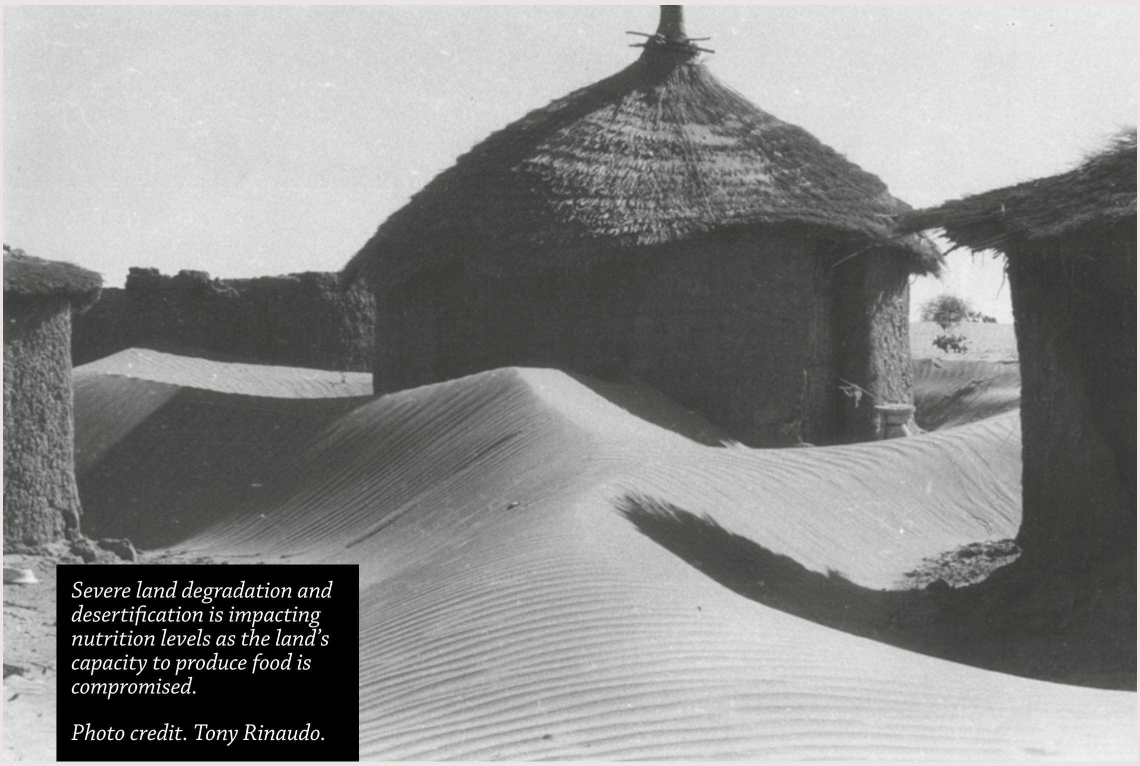
Figure 1: Vegetation map of Africa

http://printable-maps.blogspot.com/2008/09/map-of-climate-of-africa.html

Pearl millet production is becoming very marginal in the Maradi district which has previously been a major grain producing area for Niger. Unreliable rainfall, coupled with land degradation, has led to a situation where, according a former Regional Director of Agriculture in Maradi (Illiassou, 2009 pers. comm.), production is failing to deliver to expectations two years out of three, with catastrophic failure one in five years. Genetic improvements aimed at increasing productivity seem unlikely to bridge this moisture-needs gap and so the crop's long term potential is very much limited to regions with rainfall in excess of 600mm/annum (Matlon, 1990) – yet on average, no part of Niger receives this amount of rain. New shorter season pearl millets that require less rainfall have increased reliability at the expense of productivity, but crop failure remains common. In 2010, Niger will need to import more than 25 percent of its pearl millet needs, mainly from Nigeria and Burkina Faso (FEWSNET, 2009) and food access is compromised for the poor by price rises above the average of up to 17 percent in Niger's regional capitals (OCHA, 2009).

Rural livelihoods in the Sahel have always been threatened by periodic drought, and Watts (1983) shows how the inevitable hard times are etched into the consciousness of the Hausa people. When severe drought led to famine in the past, most people had the option of hunting and foraging for items of food or for sale in the bush (Belcher et al., 2005, Etkin and Ross, 1982). Humphrey et al. (1993), recorded at least 80 species that were harvested from the wild by members of a Hausa village during a dry year. Today, the opportunities for such supplementation are highly limited, and such areas as may superficially appear to be reserves of 'famine food' are more than likely crucial to someone's everyday livelihood. Years of pressure to fill human needs in successive crises – compounded by population growth – means that many plant species that have been useful in the past are now rare or have disappeared altogether (Abasse et al., 2008, Mortimore, 2003; see Maranz, 2009 for an alternative view). Thus, the range of species that can make up the Hausa diet has diminished, with a concomitant loss of nutritional potential and resilience (c.f. Grivetti and Ogle, 2000).

It is a common observation that the 'green revolution' that so boosted food production in much of the developing world had little impact in Africa (Rinaudo et al., 2002, Leathers and Foster, 2004). Certainly, there has been precious little benefit to dry-lands such as the Sahel. The 'green revolution' strategies of developing and promoting high-yielding crop varieties, supported by increased fertiliser and pesticide use, carried an innate bias to high rainfall areas, or areas



Severe land degradation and desertification is impacting nutrition levels as the land's capacity to produce food is compromised.

Photo credit. Tony Rinaudo.

where irrigation water was available. Leathers and Foster (2004) observe that farmers in areas that receive less than 40 inches (approx. 1000mm) of rainfall per year benefitted little from the ‘green revolution’: Maradi, one of the most important grain producing areas in Niger, receives only 400mm of rain per year, and even this seems to be trending downwards (Mahé and Paturel, 2009, Maranz, 2009). An important strategy of agricultural research organisations in dry-land Africa has been to increase the drought tolerance of crops. One approach is ‘drought dodging’ to reduce the risk of crop failure by shortening the time to maturation, even at the expense of total potential yield. In the case of pearl millet, varieties have been developed that mature in 60-80 days, compared to the 90-120 days typical of traditional varieties (INRAN, 2009, Mortimore, 2003; 513).

It has been argued by Rinaudo et al. (2002) that a new type of ‘green revolution’ is needed for Africa’s drylands. Rather than seeking only incremental improvements in the productivity and reliability of the existing crops, this new ‘revolution’ needs to be based on entirely new crops that are more fundamentally adapted to the variability of the semi-arid environment:

“If there is to be a ‘green revolution’ for the arid and semi-arid tropics, it will have to be through plants that thrive under such conditions, yield well and require minimal inputs. Millions of third-world farmers have no access to the usual green revolution inputs. Increasingly they are farming on exhausted, marginal lands under adverse climatic conditions that are unsuitable for conventional crops. For them, a biological revolution is needed, in which plants are selected and bred to suit the prevailing environmental conditions…” (Rinaudo et al., 2002; 167).

Maranz (2009) has argued that there is strong evidence that much of the existing savannah parklands that dominate Sahelian landscapes are the creation of human farming activities, and that these were made possible by a relatively wet period in the climatic cycle. It seems likely, therefore, that human settlements and agricultural systems are becoming ‘stranded’ in a climate drier than was the case at the time of settlement. Gradual desiccation will mean that many crops will become ever more marginal, as indeed seems to be the case with pearl millet. Under these conditions, more truly desert adapted plants seem to be an essential part of the solution. Australian acacias have enormous potential to extend the range of livelihood options whilst lessening the effects of the drier climate. Predictions of worsening desiccation in the Sahel as the effects of climate change deepen suggest that the development and promotion of acacias is a matter of urgency.

Massive biodiversity loss in recent years means that ‘wild’ food reserves have disappeared.

Photo credit: Tony Rinaudo.

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Niger: child malnutrition

Malnutrition in Niger is the result of many factors: climate, poverty, lack of access to health services, low levels of literacy, unremitting population growth, lack of nutritional knowledge, lack of food or limited food options, the powerlessness of women and a range of weaning and feeding practices. No single intervention can hope to address all of these contributing factors, many of which lie within the remit of Government education and health services.

It is not surprising that a person's nutritional status in Niger is inversely related to their power in the society. Thus men tend to be relatively well fed, with regular access to meat and sufficient cereals; women, very much more restricted to a cereal based diet, have a particular vulnerability to malnutrition during pregnancy or whilst breastfeeding; whilst children between the ages of six months and five years are highly vulnerable to malnutrition (Cooper, 2009).

According to the World Health Organization, in Niger in 2007, the infant mortality rate (0-12 months) was 83 per 1000 live births, whilst the under-five mortality rate was 176 per 1000 live births. Both measures show a slightly higher mortality rate for boys than for girls (WHO, 2008). Interestingly, household income levels have a lesser impact than might have been expected: In 2006, in the lowest wealth quintile of the Nigerien population, under five mortality was 206/1000, whereas for the highest quintile, the rate was 157/1000, giving a ratio of 1:1.3. Much more important than household wealth was the education levels of mothers: the difference between highest and lowest education levels produced a ration of 1: 2.4 (WHO, 2009). The apparent discrepancy in these figures relating to wealth and education can be explained in large part by the low status of women in Niger, and the fact that wealth is gendered in that country: a man may be wealthy, and fail to pass adequate resources to his wives (Cooper, 2009). Besides the lack of education, women are typically very limited in their opportunities to earn income, to move about in public (even to take a sick child to a clinic), have little ability to control their own fertility and may be summarily divorced leaving them with little or no support and few assets (Cooper, 2009).

Hampshire et al., (2009) and Cooper (2009) describe a number of weaning practices that also contribute to the serious levels of child malnutrition in Niger. In the first hours and days of an infant's life, there is a tendency to withhold colostrum, thus weakening both the mother/child feeding relationship, and the child's immune system. Breastfeeding is further undermined by supplementary feeding: Hampshire et al. found that: "...observations and dietary recall indicate[d] that it is common practice to give water-based infusions of medicinal plants... [to very young infants], and also that early supplementation with pearl millet-based foods is widespread" (2009; 140). Another serious issue is the practice of precipitous weaning if and when a mother becomes pregnant. Though a child will be breastfed for up to two years as an ideal, it is widely believed that when pregnant, a mother's milk will harm a feeding infant. As a result, as soon as pregnancy is known, the feeding is stopped, often overnight, by removing the child to the home of a grandmother. Writing on their study in the Tahoua and Illéla regions of Niger, Hampshire et al. comment that: "Many mothers recounted a pattern of early [breastmilk] supplementation, early subsequent pregnancy, and early and abrupt cessation of breastfeeding" (2009; 141). The weaned child is then fed a diet of pearl millet porridge 'kunu', which is insufficient in energy, protein, fat and many micro-nutrients:

> “Eating millet porridge every day is the equivalent of living off bread and water. With luck, toddlers… [in Niger] might have milk once or twice a week. Young children are so susceptible to malnutrition because what they eat lacks essential vitamins and minerals to help them grow, remain strong and fight off infections.”
>
> (SHEPHERD, CITED IN MSF, 2007)

The cereal diet delivers neither sufficient micro-nutrients nor sufficient energy to children for normal growth and development. To make matters worse, children under two years of age have a limited ability to produce the enzyme amylase, and so are limited in their ability to digest and benefit from the cereal diet (Palmer, 2009; 21).

Even children who are breastfed up to and beyond 24 months often suffer from deficiency in some micro-nutrients, which according to Palmer (2009), is usually to do with vitamin A, iron and zinc, but may also involve a shortage of iodine (Adelekan, 2003, Palmer, 2009, Tielsch and Sommer, 1984). Blum (1997) found very high levels of vitamin A deficiency amongst women in the Filingué region, a condition that could deteriorate to night-blindness during pregnancy, and which resulted in babies being born with lower than optimal vitamin A reserves and thereby a high risk of subsequent vision loss.

Hampshire points out that quality and quantity of the foods available to children are not the only issues impacting on the diets of children: “…Boule [kunu] is left in a calabash for all the family to consume at will. Because it rarely runs out… most mothers conclude that all the children have had enough to eat… foods of higher quality are distributed more formally. Men are served first, and typically get the best portions (such as meat). Children over the age of one eat from a common plate, separately from adults, who thus have little control over what, or how much each child actually eats” (Hampshire et al., 2009; 141). If a child is unwell, weak or socially withdrawn, there is a very real likelihood that she will not get a fair share of the meal: “Sick children are not usually given special foods (high quality or easy to digest); indeed cultural practices of food distribution make it very difficult for parents to single out a child for special treatment” (Hampshire et al., 2009; 142). We observed that a one year old child did not have to be unwell to miss out on a full meal, competing with two to twelve year olds during an unsupervised feeding frenzy.

The impacts of this malnutrition are normally quite gradual, but the end results are dramatic: in June 2010, WFP and UNICEF reported that Niger has acute malnutrition rates for children under five of 16.7 percent, whilst severe acute malnutrition, with high risk of mortality, was reported to be 3.2 percent (StatesNewsService, 2010). With base levels of nutrition so poor even in reasonably good years, it takes only a small livelihood shock – a drought or food price rises – to plunge the country into a full scale nutritional emergency such as occurred in 2005. During the 2005 famine, the incidence of acute malnutrition (described as 'severe wasting') in children under five was reported to have peaked at 33 percent (Gross and Webb, 2006). Sadly this scenario appears to be occurring again in 2010 (IRIN, 2010).

> "If a child is unwell, weak or socially withdrawn, there is a very real likelihood that she will not get a fair share of the meal"

In response to the 2005 famine, MSF began a widespread program of community-based treatment of malnutrition using a ready-to-eat food called Plumpy'nut. Plumpy'nut is a nutrient-dense milk and peanut-based paste, distributed in individual serve sachets, that provides an effective means by which to treat malnutrition in the home, rather than in the highly problematic clinical setting. Cooper hails Plumpy'nut as a development that: "... gave [women] a means of agency they seized upon because they could afford it and because it did not imperil their ability to meet their other obligations in the home" (2009; 22), and certainly it has proven very effective in the treatment of malnourished individuals (Amthor et al., 2009). What Plumpy'nut does not do, however, is encourage any community ownership in the food systems that underpin community wellbeing, build any resilience into agricultural systems, allow any adaptation to the changing climate or deliver any long-lasting understanding of how malnutrition might be avoided in the future. Palmer observes that:

"...[There is] a sad state of affairs in the 21st century where under-nutrition in poor countries has come to be viewed as a matter of medical prescription through healthcare systems rather than an issue of food security...the use of a ready-made food designed for emergencies should not become the norm just because public authorities neglect their basic duty to provide water and support locally sustainable food systems. The other danger of the use of such foods is that this crushes a central value of human relationships and cultures which is a family's skill to feed itself and include its youngest members in food sharing" (Palmer, 2009; 8).

The acacia/moringa (Moringa oleifera)-based kunu that is advocated here for promotion to villages is not presented as a perfect food. It is not a food that is complete in itself or that could or should replace breastfeeding. What it is, though, is a food that is dramatically better than what is current practice (i.e. pure pearl millet kunu), and which can (in theory) be entirely produced within rural villages, under prevailing climatic conditions by the poorest of people. It is, furthermore, a product that will ripple benefits through the community and farming landscape, increasing resilience and supporting livelihoods in many ways.

Australian Acacias in Niger

Within the genus Acacia, there are conservatively 1380 species, with 993 of these occurring in Australia (World-Wide-Wattle, 2004). Acacias have adapted to all ecological zones in Australia, including regions that have much in common with the extremely harsh semi-arid tropics of Niger and the Sahel more generally. Many of these Australian species of Acacia produce large crops of nutritious, tasty seed, and many have a very long history of consumption by Aboriginal Australians (Devitt, 1992, Rinaudo et al., 2002). Over the past 25 years several species of Australian Acacia have been trialled in Niger (Harwood, 1994, Cossalter, 1986, Rinaudo et al., 2002, Midgley and Turnbull, 2003). Initial experiences were mixed, and many thousands of trees planted in the 1980s died after only 2-3 years, mainly due to inadequate spacing. Since that time, knowledge of how best to cultivate Australian Acacias in the Sahel has increased greatly, whilst elite provenances have been identified for the production of seed and wood (Cunningham et al., 2008).

The species of Acacia thus far adopted in Niger (A. colei, A. torulosa, A. tumida) share many characteristics of successful crops in general: Foremost, they are species that are fast-growing pioneers. In their native environment, these Acacias grow quickly to colonise an area following a disturbance – in the Australian context this is generally fire – they seed quickly and prolifically and die off after a few years, thus first giving protection to, and then making way for, the next succession of species. Field trials in a 450mm rainfall zone in Niger have shown that with good management, and especially with appropriate pruning, A. colei can live up to 10 years; whilst A. torulosa and A. tumida will live in excess of 10 years (Cunningham et al., 2008).

Nutritional value

Seed characteristics vary between species, but protein levels are generally around 20 percent, and carbohydrate 50-60 percent. The amino acid balance is similar to other legumes such as lentils, and as such Acacia is an excellent complement to staple grains such as pearl millet, which is low in lysine. Like many legumes, Acacia seed contains anti-nutritional factors that are destroyed by heat in the cooking process. Flavour is also improved by light roasting. Screening conducted by the Australian Tree Seed Centre in 1994 indicated that Acacia colei:"... has good nutritional value and that known toxic and anti-nutritional factors were absent or at levels below those that would cause any concern" (Harwood et al., 1999). In Niger the seed is typically pounded to a flour, and then sieved to remove the hard, indigestible seed coating before being incorporated into a range of traditional foods at a proportion between 10-20 percent (Adewusi et al., 2006, Harwood et al., 1999). People who eat Acacia regularly speak enthusiastically about the seed. They enjoy the flavour, but particularly they love the lasting feeling of satisfaction that they get from a meal of Acacia (Cunningham and Abasse, 2005). It is common to hear people say that they are able to work all day in the fields if they add it to their breakfast. Another very common observation is that Acacia "brings down a mother's milk". Whether this property is simply a result of better nutrition being available to the mother, or whether there is another bio-chemical property at play (similar effects have been widely documented for other legumes including fenugreek (Gabay, 2002)), this is a quality for which Acacia is highly appreciated.

Desert bounty: Aboriginal woman bringing home heavy harvest of Acacia corriacea.

Photo credit: Oliver Strewe

Detailed analysis of Acacia colei seed

In September 2010, I requested a detailed nutritional analysis from the Australian Government's National Measurement Institute, of Niger-grown Acacia colei seed that had been prepared for use as food. The preparations involved light roasting, after which the seed was milled and sieved to remove most of the indigestible seed coat. I felt it important to measure the actual nutritional value of the prepared seed, since roasting can affect several aspects of nutrition, including protein content and composition, and the presence of high levels of fibre (the seed coat), can impede nutrient availability. The results of the analysis are presented right in Table 1.

Heavy seed yield of Acacia colei.

Credit: Oliver Strewe.

Table 1: Results of Acacia seed nutrition analysis

Analysis conducted by National Measurement Institute, Melbourne, Australia, September 2010.

Amino Acids	units	
Alanine	mg/g	9
Arginine	mg/g	16.9
Aspartic acid	mg/g	21.9
Glutamic acid	mg/g	36
Glycine	mg/g	9.4
Histidine	mg/g	6.4
Isoleucine	mg/g	8.9
Leucine	mg/g	17.4
Lysine	mg/g	14.9
Methionine	mg/g	1.9
Phenylalanine	mg/g	9.9
Proline	mg/g	10.6
Serine	mg/g	11.1
Threonine	mg/g	7.7
Tyrosine	mg/g	7.8
Valine	mg/g	10
Total Amino Acids	**mg/g**	**199.8**

Proximates	units	
Protein (N x6.25)	g/100g	27.4
Ash	g/100g	4.3
Carbohydrates	g/100g	21
Total Sugars	g/100g	3.6
Total Dietary Fibre	g/100g	24.3
Moisture	g/100g	7.6
Energy	kJ/100g	1580
Total Fats	**g/100g**	**15.3**

Trace Elements	units	
Calcium	mg/100g	180
Copper	mg/100g	1.5
Iron	mg/100g	52
Magnesium	mg/100g	200
Phosphorus	mg/100g	280
Potassium	mg/100g	1100
Sodium	mg/100g	3.7
Zinc	mg/100g	2.9

Vitamins	units	
alpha-carotene	µg/100g	<5
Ascorbic Acid	mg/100g	<1
beta-Carotene	µg/100g	130
Thiamin	mg/100g	0.08
Total Folates	µg/100g	190
Riboflavin (B2)	mg/100g	0.06
Niacin (B3)	mg/100g	1.1
Retinol (Vit A)	µg/100g	<5
Pyridoxine (B6)	mg/100g	0.29

Seed production

The first crops of seed are generally harvested 18 months after planting. Yield is influenced by species, provenance, rainfall and to some extent other climatic factors such as wind. Amongst the species/provenances currently favoured in Niger, rainfall below around 300mm/annum is likely to seriously reduce seed production . Future selections of species better adapted to arid conditions (such as A. murrayana, A. melliodora and A. jennerae) may increase both the reliability of seed yield in dry years, and the potential range of Acacia production in the Sahel. Selection and trialling of such species should be undertaken as a matter of urgency. Agronomic practice is also an important determinant of seed yield, particularly factors such as tree spacing, weed control and pruning. Trials of a branching provenance of A. torulosa in the Maradi district by Peter Cunningham of the NGO Serving In Mission (SIM) produced an average of around 4.5kg of seed per tree from 64 trees. The record seed yield for an individual tree in Maradi, Niger (A.colei) was a staggering 14kg (Cunningham, P., pers comm). It is a 'rule of thumb' across Africa that on-farm production is around 30 percent lower than is achieved on research facilities, so that an average of closer to 3kg per tree may be a realistic expectation. With future plantings based on the best provenance selections, good silvicultural practice and taking into account years of poor rainfall, a yield of >1kg per tree is a fair annual expectation (Cunningham and Abasse, 2005).

Acacia torulosa seed ready for processing.

Photo credit: Peter Cunningham.

Timber use

The short life-span of Acacias was at first thought to be a potential limiting factor for their use in agricultural settings, but agronomic work in Niger has demonstrated that the life span of the trees can be greatly increased through heavy pruning every two years. In field trials, the wood produced through pruning has made a major contribution to farm and household incomes. Field trials by Peter Cunningham measured wood production from well spaced mature A. colei. The researcher estimated that each tree produces approx 250 cfa (AUD $0.54) of wood from prunings each year, resulting in 500 cfa (AUD$ 1.08) equivalent every 2nd year (as pruning is recommended every 2nd year). In an agroforestry system of the type promoted by Cunningham and SIM, with 107 A. colei trees, the result is approx 30,000 cfa (AUD$64.70) of wood value per year. This would be more than half the expected pearl millet crop value of 50,000 cfa (AUD$107.93) per annum (P. Cunningham, Pers. Comm.).

Fuelwood

All rural cooking and most urban cooking in Niger is done with wood, and acacia is considered to be excellent. The market for fuelwood is very strong in Niger, and this places heavy pressure on remnant native woodlands. A scaled up adoption of Acacia will provide a sustainable alternative, a fact that is well recognised by the Niger Forestry Department who have exempted all (Australian) acacia wood from forest taxes. It is also important to note that the Australian acacias are very rapid wood producers, anecdotally four times faster than Acacia Senegal, the best of the African acacias.

Energy

Though the wood market is large and robust, it is conceivable that a future scale-up of Acacia production could generate volumes of wood in excess of the market's capacity. Should this situation eventuate (and it would take several years), wood could be burned, depending on market conditions, to produce electricity and bio-char. Electricity can be fed into the national grid and bio-char interred on farmland to claim a carbon sequestration price on international markets, and to realise significant fertility enhancing benefits (Lehmann and Joseph, 2009).

Building materials

The Australian acacias have been shown to grow and produce wood at least four times faster than the best African acacia species. Some innovative farmers have seized on this opportunity and have started producing tall, straight building poles. The scarcity of building materials makes these poles extremely valuable – so valuable, indeed, that one wonders why a farmer would even bother with a cereal crop. An analysis by the forester Jon Lambert has suggested that growing Australian acacias for poles could exceed the profitability of agroforestry by around four times, and annual pearl millet crops by over seven times (Jon Lambert, pers. comm., 2010). Though growing for poles does not preclude some seed harvest, tree management tends to favour either seed production or wood production. In the future, provenances specifically selected for pole production are expected to be available. Smaller branches are regularly used in building also, principally as roof battens. Even the seed pods have a role in building, being pounded and added to mud-mortars to increase their resistance to rain.

Firewood is a readily saleable commodity in the Sahel and an added incentive for farmers to grow acacias.

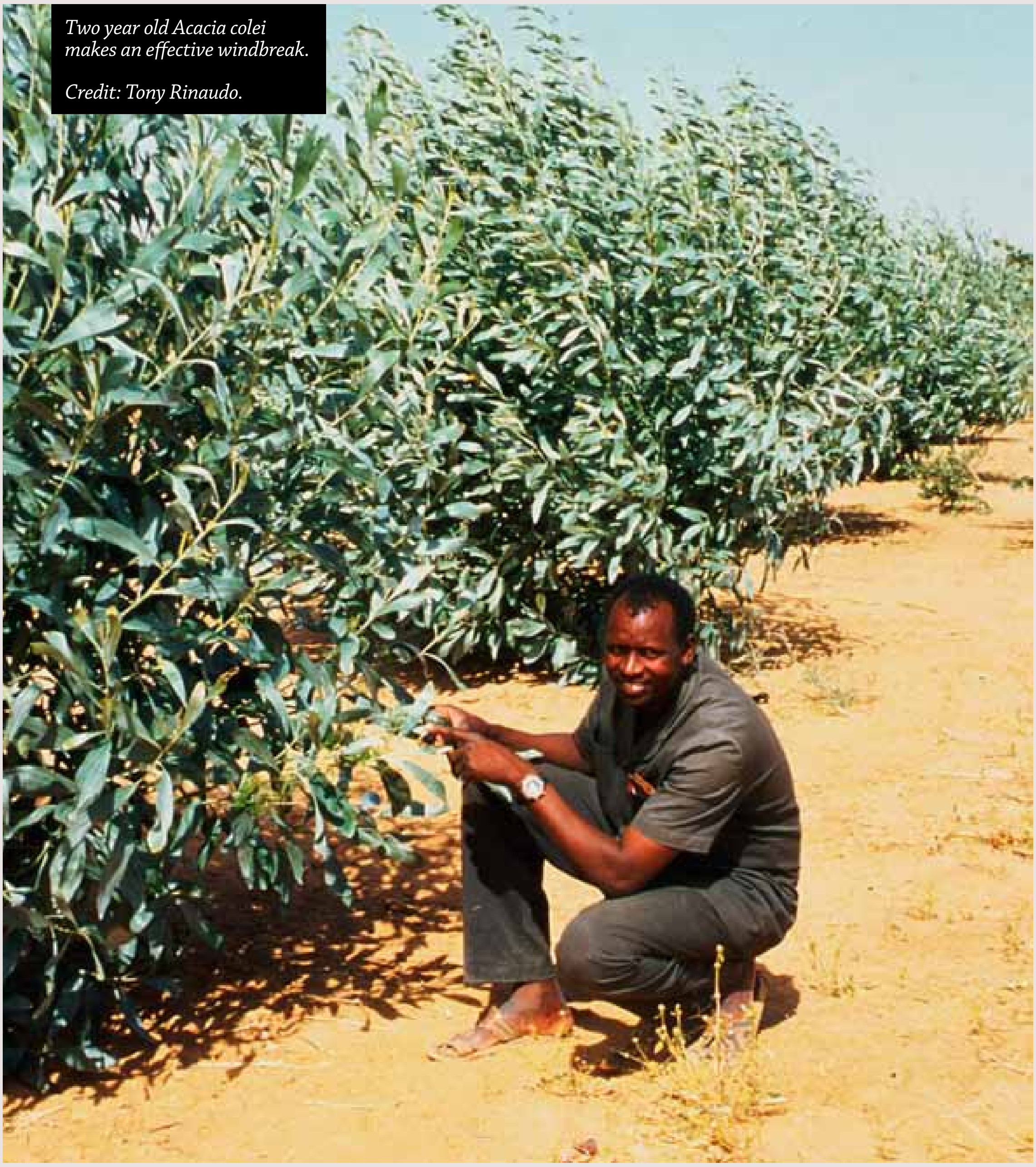
Photo credit: Peter Cunningham.

Agricultural benefits

The contribution of the Australian acacias to livelihoods in Niger is not restricted to their direct products. The trees greatly increase agricultural resilience by supporting a range of ecological processes and ameliorating extremes of climate.

Bee forage

Honey production is an important livelihood activity for some people in Niger. Acacias flower profusely, and though not renowned for their nectar, offer a useful seasonal supplement to the very limited bee forage that is available in many areas.



Two year old Acacia colei makes an effective windbreak.

Credit: Tony Rinaudo.

Mulch

Pruning yields not just wood but a large amount of leaf material. Leaves can be left on the surface as mulch, to slow soil drying and to be slowly interred and recycled through termite activity; or they can be buried in 'zai' holes for a more rapid recycling of nutrients. The value of mulch cannot be underestimated given the extremely high temperatures of bare, exposed soils and the low moisture availability, and inherently low soil organic matter levels.

Windbreaks

Wind can be a very destructive force in Sahelian agriculture, and Rinaudo has observed farmers having to replant pearl millet crops up to five times as each successive crop emerges, only to be buried or sand-blasted (Rinaudo et al., 2002). Plantings of Acacia on field boundaries and within fields helps reduce wind speeds, slows desiccation and causes suspended organic matter, silt and sand to fall from the air – the reverse of soil erosion in fact adding nutrients to the soil.

Nitrogen fixing

All Acacias in Australia are regarded as having nitrogen fixing potential (Turnbull, 1987). Whether this potential is fully realised in the species that have been taken to Niger is unclear. Most people who have a long term involvement with the trees feel that there is at least some benefit, however Dr Dov Pasternak of ICRISAT found no sign of nodulation on the roots of A. colei or A. torulosa, and concluded that there is no nitrogen fixing benefit (Pasternak, pers comm, 2009). On the other hand, Remigi et al. (2008) found strong evidence of nitrogen fixing rhizobial associations in Acacia holocericea (a species closely related to A. colei), in dry land regions of Senegal. Cunningham comments that: "We have identified nodulation on all Acacia species- especially A. colei in the Maradi tree nursery. A. colei is very promiscuous for nodulation with root nodule bacteria. 75-100% of all strains tested were able to form nodules. This is significant and born out in our observations. Native Rhizobium from A. nilotica, F. albida and A. senegal can nodulate A. colei" (P. Cunningham, Pers. Comm.). Since the potential exists, it may simply be a matter of identifying and collecting appropriate microbial assemblages from the Australian environment, and using these to inoculate the Niger-grown trees (Duponnois et al., 2007).

Livestock forage

The foliage of some species of Australian Acacia are highly palatable to livestock. Of particular note are A. victoriae and A. saligna, the latter of which has been planted extensively in Tigrai, Ethiopia. The species thus far being used extensively in Niger have been successful in part due to their lack of palatability. More tasty selections are simply, and very promptly, destroyed by goats, sheep, cattle, donkeys or camels.

The green Acacia pods are often fed to livestock to encourage fattening, and seed is often given to nanny goats following parturition to encourage the milk (just as is the case with human mothers – in fact the phenomenon is reported to have been first observed in goats). The seed coatings sieved out of the Acacia flour is usually given to sheep or goats, which devour it with relish. Whereas livestock tend to ignore green leaves of A. colei, the leaves can be made palatable to livestock by drying and pounding, though they are of low nutritional value.

Australian Acacias in the agricultural system

SIM in Maradi has developed an agroforestry system based on Acacias, which it calls the Farmer Managed Agroforestry System, or FMAFS. The system is highly flexible to farmer preference, but broadly involves Acacias (usually at least two species), planted in rows on or near the field boundaries, and a number of other rows within the field. Intercrops such as pearl millet, sorghum, peanuts, hibiscus or cowpeas are grown between the rows of Acacia on a rotating basis. All crop residues are mulched or added to zai holes (Cunningham et al., 2008). Acacias generally need to be pruned in the third year, and every second year thereafter, just before the rainy season, to reduce moisture competition with annual crops. Additional tree species are encouraged, including any remnant native species, but also useful and high value specimens such as Zizyphus mauritania, Moringa stenopetala, Sclerocarya birrea, Adansonia digitata and others.

The economics of the FMAFS system are still under investigation, but early results show a dramatic improvement in farm income:

Table 2: Average annual economic benefits from a 1 ha FMAFS at Maza Tsaye (2007-2009).

FMAFS component	Product yield (Kg/ha)	Value (cfa)
Pearl millet	640	24,000
Sorghum	475	21,400
Cowpeas	390	36,560
Hibiscus	270	13,500
Peanuts	25	2,300
Wood (Acacia)	120	3,000
Agropodon grass		6,000
Total		**106, 760**

Control comparison. Traditional monoculture pearl millet farm. Niger: Average annual pearl millet & Sorghum production 445 and 335 kg/ha (2003-2007).

(Cunningham, 2009)

Table 3: Average annual economic benefits from a 1/2 ha FMAFS vs. control farm at Magajin Kware (2007-2009).

FMAFS Component	FMAFS (cfa)	Control (cfa)	% Increase
Annual crops	34,630	11,460	202
FMNR wood	6,500		
Acacia wood	5,660		
Acacia seed	10,750		
Total	57,540	11,460	502

(Cunningham, 2009)

The farmer managed agroforestry farming system integrates perennial species, including Australian acacias and annual crops in rotation and utilizes conservation agriculture principles.

Caption: Peter Cunningham.

On weediness

The potential for exotic plants to become invasive is a perennial concern in parts of Africa. In South Africa, 180 exotic species, including Acacias from Australia, have been classified by the Government as 'invasive alien plants' (Turpie, 2004, Yelenik et al., 2004, Richardson and van Wilgen, 2004, Le Maitre et al., 2004). Such plants, it is argued by Le Maitre et al., globally cost as much as US$314 billion per year, and cost "South Africans tens of billions of rand annually in lost agricultural productivity and resources spent on weed control" (2004;103). The case for great caution in the introduction of an alien plant with the potential for invasiveness is thus very clear. Nevertheless, it is also true that the forces that bear on the introduction and dispersal of alien species are complex. Human agency plays a big part, and 'invasive alien plants' have been embraced as often as they are hated (Kull and Rangan, 2008). According to Shackleton et al.:

"While the negative impacts of [alien invasive species] on ecosystem structure and function are undisputed, understanding of their potential impacts on rural livelihoods and well-being is less developed, especially since it is their land and waters that are most affected by [alien invasive species]. It is tacitly assumed that the harmful impacts on ecosystem goods and services automatically translate into negative effects on human wellbeing. Yet, [alien invasive species] are frequently integrated into local livelihoods, both as managed species, as well as exploitation of wild invasive populations" (2006;113).

De Neergaard et al. are very clear about the importance of exotic acacias for rural livelihoods: "For local rural communities the wattle serves as a valuable resource providing firewood, building materials and in some instances... cash income... Although the species may encroach on grazing land, the problems related to the spread of the wattle such as reduced stream flow, competition with indigenous species, etc., are often not a particularly pertinent issue to rural communities who seek to use this resource as a part of their livelihood strategy. There is a potential conflict between the perceived interests of society (control of the wattle) and local communities (a continued resource of woody species)" (de Neergaard et al., 2005;218). There is, furthermore, a strong likelihood that the existence of a wood resource comprised of alien species can actually help to protect ecosystems by deflecting some of the fuelwood harvest from native vegetation.

Acacias have been grown in Niger for well over 25 years. Little sign of weediness has been observed (Rinaudo et al., 2002, Thompson et al., 1996). There are a number of reasons for this:

- The dormancy of Acacia seed in its natural habitat is usually broken by fire. In the agricultural landscapes of the Sahel, there is virtually no fire to perform this task.
- Young seedlings are highly vulnerable to grazing and trampling by livestock.
- Trees are a valuable resource in the Sahel. If a tree is not clearly owned and actively guarded it will be cut or grazed remorselessly. There are no woody weeds where wood is so valuable!

In June 2010, I conducted a 'quick and dirty' weediness survey at the Danja Hospital farm site, where Acacia colei and A. torulosa have been grown in trials for over 15 years. I set out to conduct a formal survey, counting the occurrence of volunteer trees and seedlings along a set of transects. On the ground, however, it quickly became clear that there was little point in such an approach, since there were so few volunteers, and those that were there were found in

only a few very specific niches. The area I examined was a mix of farmland, typically growing annual crops of pearl millet, with most field edges demarcated with rows of A. colei or A. torulosa, and highly degraded pastoral land (in fact, a stock route). My survey was at the end of the dry season. Early rains had fallen, but these would have been insufficient to produce any new season germinants. Thus all trees and seedlings observed were from 2009 or earlier.

The observations I was able to make were as follows:

- The vast majority of seedling volunteers were A. colei (>95 percent). There were very few seedlings of A. torulosa, and the few I found looked to be struggling, though with the rains due, these could be expected to revive before long.
- Germination occurred both within fields and on field borders, however for seedlings to survive within fields required that the farmer choose to retain the tree – a small seedling is easily chopped out with the hoe along with other 'weeds'.
- Where older trees occurred within fields, there was clear evidence that most of these trees were wanted by the farmer: they had often been pruned to encourage a tall stem suitable for use in building.
- Seedlings found in field borders were struggling to compete with the pre-existing, mature trees (a mix of A. senegal, A. nilotica, Guiera senegalensis, Bauhinia reticulata and Prosopis ssp).
- The few seedlings I found on the pastoral land were weak and stressed. All showed signs of having been grazed, and all were germinants of the previous season only; there were no trees in these areas older than 12 months, suggesting that tree survival is very difficult in such areas of 'commons', where ownership and rights are both dispersed and contested.

Acacia torulosa in bud.

Credit: Tony Rinaudo

Field work: design, process and outcome

Approach

My research process was strongly informed by the belief that local capacities and resources should be engaged wherever possible. To this end, it was important to consider how any proposed intervention is built on existing local knowledge, and how local resources and institutions can serve to sustain it over the longer term (c.f. Mortimore, 2003). It was important that I worked with people who were familiar with Australian acacias, both as elements in the agricultural system and as food. This proved a relatively easy condition, since World Vision Niger and SIM have been actively promoting Acacias in the district for several years, and maintain excellent working relationships with many villages in the district.

My research approach was to consider the various factors that might impact on the success of an Acacia-based food. Thus attention was to be paid to production issues, compatibility with overall agricultural systems, price and price fluctuations, farmer acceptance of Acacia as a crop, taste acceptability and 'fit' with local cuisine. A further set of considerations dealt with the quality, food safety and nutritional requirements that an emergency food product would have to meet.

My initial research target was to explore the feasibility of using acacia seed as the protein and carbohydrate basis of an emergency food product. My design criteria were:

- That the product contain a significant proportion of acacia seed;
- That the product be able to be made using, as far as possible, local ingredients. Specific nutritional components were to be sought in whole food products that are available locally in Niger, rather than in imported supplement form;
- That the product be as nutritionally complete as possible, to cover as wide a spectrum of a target population as possible;
- That the product fit well into West African cuisine(s);
- That the product be cost effective compared to other forms of nutritional support; and that
- That the product have a long shelf life.

Prior to entering the field, I developed the concept tentatively as a biscuit, comprised primarily of pearl millet, acacia, peanut, date and moringa leaf. The biscuit was tasty and filling, if somewhat heavy in texture, so that to eat the 500grams required to deliver a day's energy quota would have been something of a challenge!

Refining the target

The target population for the food product was also important. I was advised by Colleen Emary of World Vision Canada that the area of greatest need was in ‘complementary foods’, that are used alongside breastfeeding, or to replace breast milk if this method of feeding is terminated for any reason. The complementary foods suggestion was well backed up by the available evidence, considering that a disproportionate amount of the suffering and death due to malnutrition and famine is borne by children aged between six months and five years.

Acacia elacantha in flower.

Credit: Tony Rinaudo

A Hausa initiative

In the field in Maradi, I was reacquainted with a farmer called Baro who I had met on my two earlier visits. After telling Baro the reason for my visit – to develop a complementary food based on acacia seed – I was extremely surprised to hear that he had in fact been making and distributing just such a food for several years.

Baro is a farmer who has a long history of working with acacias. He is a member of the small Christian community in the Maradi region, and this perhaps both gave him easier access to the agricultural teaching of the SIM missionaries and made him more receptive to the new ideas he would receive. Baro was very quick to see the benefits of using acacia on his farm and became a key innovator, developing himself many of the silvicultural practices that have become standard in the management of acacia trees.

With very many acacia trees on his farm, Baro is a significant producer of acacia seed, and held a large stock of seed. With the unfolding famine in 1988, he saw many children in his village developing signs of malnutrition, and was moved to take such action as he could. He began producing a simple kunu mix, containing pearl millet and around 20 percent acacia flour, and giving this to mothers whose children were failing. The food was well received, and Baro was kept busy (and stretched financially) providing acacia/pearl millet kunu to the many women who approached him from his own and neighbouring villages.

As the famine conditions eased, women continued to approach Baro, asking for the acacia/pearl millet kunu. Understandably, he was unable to afford to keep giving the mix away, and offered to sell it instead. He has been involved in a small but regular trade since that time, and the value of his acacia/pearl millet kunu in childrearing is well-recognised in and around his village.

Baro's kunu formulation was very simple, being just acacia seed and pearl millet. As such it was definitely an improvement on the pure pearl millet kunus that most village children were fed. The acacia seed was particularly important in boosting protein intake, both in overall terms and by providing a better balance of amino acids, since acacia seed is high in lysine, in which pearl millet is very low. The mix was still seriously lacking in energy, fat and several micro-nutrients however, and I offered to work with Baro to see if we could improve the nutritional profile of the kunu.

We also approached three women; Hadiza, Mariama and Rahilla, who had worked with SIM for many years (since 1984 in the case of Rahilla) conducting acacia food demonstrations in the villages around Maradi. The three women were all experts in the preparation of acacia and other grains, in Hausa cuisine, and were mothers with a total of 18 children between them! I was also assisted by Anna Szava, a colleague and prospective student of child nutrition in developing world settings. Hadiza was especially important, acting as an interpreter between English and Hausa.

Local sources of nutrition used in the study

Moringa oleifera and M. stenopetala

Acacia seed alone does not offer a balanced diet. In this respect, Moringa, which also thrives under Sahelian conditions, could substantially complement the nutritional shortfalls of acacia seed. The leaves of Moringa ssp, especially M. oleifera and M. stenopetala, are exceptionally high in vitamin A, iron and calcium, and are also very high in protein, with an excellent amino-acid balance (Price, 2007, de Saint Saveur, 2001, Nambiar and Seshadri, 2001).

There are several species within the genus, and two of these have particular value in human nutrition: Moringa oleifera has been highly developed as a crop in India and the Philippines, whilst Moringa stenopetala has until recently been largely restricted to Ethiopia. Both species are well adapted to the semi-arid tropics, being able to shed their leaves in the dry months in order to conserve moisture, however when trees are grown commercially for leaf, irrigation is required to extend production into the dry season.

In India, Moringa oleifera is valued for its nutritious leaves, young seed pods and quality oil. A wide range of cultivars, variously selected for leaf or pod production, or for drought tolerance or other qualities, have been developed in India. One of these, an elite fast growing high pod-producing , variety called PKM1 is being widely promoted in the Sahel by ICRISAT. In Niger the tree is well known, and is widely grown in agroforestry systems and as singular trees in family compounds. Gametie and de Saint Sauveur, (N.D.) describe M. oleifera production methods for a region near Niamey, Niger and demonstrate that with irrigation the economics of M. oleifera production are very encouraging. In Niger even without irrigation there are compelling reasons for growing Moringa. As humidity increases before the onset of the first rains moringa bursts into leaf, often providing the only food locally available during the hunger gap (from when grain stores are depleted and the next harvest is still months away). Moringa leaves are commonly available in Niger in the marketplace as a semi-prepared food: the leaf is boiled and pressed into a ball prior to being dried in the sun. In this way the vegetable is made available throughout the dry season.

M. stenopetala is a graceful tree with a somewhat weeping habit from Ethiopia. Abuye et al. (2003) estimate that in excess of “five million people depend on this plant as a vegetable source…one plant of M. stenopetala is able to support a large family” (2003; 247). Analysis by Abuye et a.l (2003) indicates that Moringa stenopetala is lower in protein and most micro-nutrients than M. oleifera, though it still contains very significant quantities of the key micro-nutrients, vitamins A and C, and iron. Moringa stenopetala is more drought tolerant than M. oleifera, and produces an impressive volume of large, easily harvested leaves (though Jiru et al (2006) found M. oleifera dramatically more productive than M. stenopetala in Ethiopia, probably due to the latter’s vulnerability to pest attack). In a note of caution, Abuye et al. note the presence of cyanogenic glucosides in the leaf material which may potentially be a problem in areas with endemic goitre and hypothyroidism if large quantities of leaf are consumed over long periods (2003; 250, see also Bennett et al., 2003). No work has been published on the economics of M. stenopetala production in Niger, however early suggestions are that it will be more profitable in the dry environment.

Other key ingredients

Pearl millet is a cultural ‘keystone’ food of the Hausa, and is eaten at virtually every meal. Pearl millet remains the basis of the children’s food kunu. It delivers important energy, protein and micro-nutrients, but lacks the nutritional density on its own to deliver sufficient quantities of any of these to a growing child. I argue therefore that several additional ingredients need to be added to provide w1hat cannot be found in millet. Peanut is a common local crop that is rich in fat, and therefore much needed energy, as well as protein. Acacia adds protein and carbohydrate, whilst Moringa is included primarily for its rich vitamin A and iron content. Sesame seed offers a rich source of calcium and also fat. Sugar adds palatability and a source of energy. Iodised salt provides electrolytes and iodine as a preventative to hypothyroidism. Baobab fruit pulp is rich in vitamin C and calcium, though its utility is questionable in a kunu mix since much of the vitamin C will be lost in the cooking process.

Ingredient nutrition

Table 4: Nutritional content of potential ingredients for a complementary food (from published sources).

		Carb - g/100g	Protein - g/100g	Fat - g/100g	Energy - Kj/100g	K - Mg/100g	P - Mg/100g	Ca - Mg/100g	Fe - Mg/100g	Zn - Mg/100g	Vit. C - Mg/100g	ß-caro - µg/100g	Vit. A - µg/100g	Source
Moringa oleifera	fresh leaf	13.4	6.7	1.7	385	259	70	440	7	--	220	--	6800	(Price, 2007)
	dry leaf	38.2	27.1	2.3	858	1324	204	2003	28.2	--	17.3		16300	(Price, 2007)
Moringa stenopetala	fresh leaf	51.8	9.0	5.8	1236	453	65.6	792	3.08	0.53	28.07	160	--	(Abuye et al., 2003)
	dry leaf													
Adansonia digitata (Baobab)	fruit pulp	75.6	2.3	0.27	--	2.31	100	293	--	--	290	--	--	(Manfredini et al., 2002)
Pennisetum glaucum (Pearl Millet)	seed	63.3	11.1	4.2	1489	195	--	8	3.0	1.7	0	0	0	(NUTTAB, 2009)
Acacia colei	seed*	21	27.4	9.2	1580	1100	280	180	52	2.9	<1	130	<5	National Measurement Institute, Sep10
Soya bean	seed	30.2	36.5	19.9	1741	1797	704	277	15.7	4.9	6.0	--	2.0	USDA Nutrient Database
Sesame	seed	0.9	22.2	55.6	2530	170	--	62	5.2	5.5	0	5.0	--	(NUTTAB, 2009)
Peanut	roasted	14.1	25.1	52.7	2661	620	--	40	1.2		0	4.0	2.8	(NUTTAB, 2009)
Sugar		100	0	0	1600	2	--	1	0	0	0	0	--	(NUTTAB, 2009)
Salt	iodised	--	--	--	--	--	--	--	--	--	--	--	--	--

Lightly roasted and with seed coat removed

The collaboration process

That kunu – a thin pearl millet or sorghum based porridge – was an appropriate product on which to focus my research seemed clear enough based on Baro's earlier success. This was readily affirmed by the new team members, and so we began a process of sharing knowledge, and surveying the potential ingredients that could be used in a kunu. With the exception of iodised salt and sugar, we tried to look only at ingredients that were produced locally. This was based on a desire to maximise the market opportunities for local farmers should mass production of the product for distribution as a nutritional supplement come to pass, and also to ensure that the product was comprised entirely of ingredients that lie within the experience and knowledge of rural people. Were this not the case, the likelihood of widespread adoption would be greatly diminished: if foods are not available in local markets, if they are expensive, or they are simply unfamiliar, the team felt that people would be reluctant to use them.

A survey of markets in Maradi and Sabon Marche yielded the same basic list: pearl millet, sorghum, cowpea, sesame, peanut, roselle and moringa leaf. Soybean was added to the list as it is also widely available and well known as a good food, though it is grown well to the south, in Nigeria. Another Nigerian import was added at the suggestion of Hadiza: garin kuka - the pulp of the baobab fruit, which is very high in vitamin C. The other ingredient, and the raison d'être of the study, was of course, acacia seed.

The team discussed the relative nutritional benefits of the various ingredients, and then launched into a series of cooking experiments. The objective was to use a selection of ingredients – always including acacia seed – to produce a kunu with a good taste and appearance. Each recipe was assessed for nutritional content using NutriSurvey, a linear programming application and nutritional database, and the results were fed back into subsequent recipes.

Some important design constraints emerged quite early in the process:

- Cowpea was not considered a suitable food for babies. I was unable to ascertain any particular reason for this – it was simply a baldly stated fact: that people will not feed cowpea to their young children.
- Colour was regarded as important. The inclusion of higher amounts of moringa leaf would add considerably to levels of micro-nutrients, in particular iron and vitamin A, however nutritionally optimal moringa levels led to a distinct green colour, which was felt to be unacceptable by the design team. I was told the green colour would lead mothers to fear that the food contained 'medicine', ie dangerous and possibly magical herbs.
- Despite the reluctance to use cowpea, soybean was believed to be a good food for children, and the group were keen to include at least some in the mix.

In addition, there were design considerations that I brought to the process based on my experiences working with acacia seed in Australia, and on my preparatory readings:

- Acacia seed should be lightly roasted, and the seed coating sieved out. Roasting greatly improved the flavour, and also helped to destroy anti-nutritional factors in the seed. Removal of the seed coat reduced fibre levels. This is desirable in the context since high fibre levels can constrain micro-nutrient absorption.

- Moringa leaf is a popular and widely consumed vegetable in Niger, and is widely available in the marketplace. This readily available product may be of lessened value nutritionally however, since the processing methods to which it is subjected are sub-optimal. The standard method for moringa leaf preparation involves boiling the leaves, then discarding the water, after which the pulp is pressed into small cakes and dried in the sun. Vitamin A is reported to be reduced greatly by exposure to direct sunlight (Price, 2007). Thus the production of a nutritious kunu would require the establishment of a processing protocol wherein the leaf is dried in the shade prior to grinding to a powder.

After several versions of kunu had been mixed, cooked, tasted, nutritionally assessed and discussed, the group set about taking the best recipes in terms of taste and nutrition, and trying to capture the best elements of each in a single recipe. This was an interesting and contested process, as some members of the group strongly favoured the sweeter mixes (and would add large amounts of sugar to any batch they were tasting), with rather less concern for nutrition. At the other extreme, in the interest of high vitamin A and iron levels, I was pressing for Moringa to be included at 8 percent, then 5 percent, and was finally able to reach agreement at a mere 3 percent, at which point the resulting colour was deemed acceptable 'to the village women'.

Another point of contention was the levels of soybean flour to be included. Soybean is a non-local crop and is generally too expensive for rural people to afford, though it is available in most rural markets. Soybean has been promoted widely as a good element in food for children, through nutritional programs such as those run via Government clinics and through a SIM child and maternal health education program. I argued that acacia seed was a reasonable, and importantly, local, substitute for soybean. A compromise reduced soybean content to a low 5 percent, whilst boosting acacia seed to 15 percent.

Fortified kunu product produced by enterprising women working with the author.

Photo credit: Peter Cunningham.

The initial recipe

Pearl millet (pounded/milled and sieved of chaff, lightly roasted)	**55%**
Peanut (roasted)	**15%**
Acacia seed (roasted, pounded/milled and sieved of most seed coating)	**15%**
Moringa leaf (shade dried and milled to powder)	**3%**
Sesame seed (roasted)	**5%**
Soybean (roasted)	**4%**
Baobab fruit (powder)	**2%**
Sugar	**10%**
Salt (iodised)	**1%**

Table 5: Nutritional analysis of initial kunu mix

Analysis conducted by National Measurement Institute, Melbourne, Australia, September 2010.

Proximates	units	
Protein (N x6.25)	g/100g	15.2
Ash	g/100g	2.8
Carbohydrates	g/100g	55
Total Sugars	g/100g	14
Total Dietary Fibre	g/100g	8.8
Moisture	g/100g	5.7
Energy	kJ/100g	1740
Total Fats	**g/100g**	**13**

Amino acids	units	
Alanine	mg/g	6.9
Arginine	mg/g	9.7
Aspartic acid	mg/g	12.5
Glutamic acid	mg/g	25.4
Glycine	mg/g	4.5
Histidine	mg/g	2.9
Isoleucine	mg/g	5.0
Leucine	mg/g	10.7
Lysine	mg/g	4.5
Methionine	mg/g	1.7
Phenylalanine	mg/g	6.3
Proline	mg/g	6.6
Serine	mg/g	5.8
Threonine	mg/g	4.1
Tyrosine	mg/g	3.5
Valine	mg/g	5.8
Total Amino acids	**mg/g**	**116.0**

Vitamins	units	
alpha-carotene	µg/100g	<5
Ascorbic Acid	mg/100g	2.0
beta-Carotene	µg/100g	29
Thiamine	mg/100g	0.14
Total Folates	µg/100g	130
Riboflavin (B2)	mg/100g	0.03
Retinol (Vit A)	µg/100g	<5.0
Pyridoxine (B6)	mg/100g	0.46

Trace elements	units	
Calcium	mg/100g	66
Copper	mg/100g	0.64
Iron	mg/100g	8.3
Magnesium	mg/100g	120
Phosphorus	mg/100g	260
Potassium	mg/100g	460
Sodium	mg/100g	240
Zinc	mg/100g	2.4

Table 6: Comparison of initial Acacia/Moringa kunu against international standards and millet kunu.

Based on 100g kunu (dry) daily intake for an infant aged 6-8 months. FAO/WHO (2002), unless otherwise indicated.

Nutrient	Unit/ day	Acacia/ Moringa kunu Measured Content	Recommended Daily Intake (RDI)	% of RDI provided by Acacia/ Moringa kunu	Pure pearl millet nutrition values	% of RDI provided by pure pearl millet kunu
Energy	Kj	1740	2574	67%	1489	58%
Protein	g	15.2	9.1	167%	11.1	122%
Total Fat	g	13	30	43%	4.2	14%
Carbohydrate	g	55	95	58%	63.3	67%
Thiamine	mg	0.14	0.3	47%	--	--
Riboflavin	mg	0.03	0.4	7.5%	--	--
Niacin	mg	3.1	1.5	206%	--	--
Vitamin B6	mg	0.46	0.3	153%	--	--
Folate	µg	130	32	406%	--	--
Vitamin A (Retinol Equivalents)	µg	<5	400	1%	0.0	0%
Vitamin C	mg	2.0	30	7%	0.0	0%
Calcium	mg	66	400 (270)	16%	8.0	2%
Phosphorus	mg	260	400	65%	--	--
Zinc	mg	2.4	4.1	60%	1.7	41%
Iron	mg	8.3	9.3	89%	3.0	32%
Magnesium	mg	120	54	222%	--	--
Copper	mg	0.64	0.3	213%	--	--
Sodium	mg	240	350 (170)	68%	--	--
Potassium	mg	460	700	66%	195	28%

Discussion

The attempt to compare the nutritional value of either the Acacia/Moringa kunu, or a kunu made from millet alone, against accepted nutritional standards was challenging. Whilst a broad and general assessment of nutritional content is easily achieved, any attempt to be definitive inevitably meets with problems. Firstly, the science of defining 'Recommended Daily Intakes (RDIs)' for various nutrients, (not to mention 'upper limits' or 'estimated average requirements'), is a highly complex branch of bio-chemistry, and little agreement is to be found amongst experts. Secondly, differences between continents and regions are significant. In Table 6 above I have used RDI data derived from three different sources, two of which can be considered to be international standards. Where a very large discrepancy in RDI values exists between authorities, I have attempted to show the magnitude of this discrepancy. Thirdly, there is the question of data quality: without an exhaustive and expensive process of analysis, one is reliant on published nutritional data for many ingredients, which may often be inaccurate or unrepresentative of actual nutritional content. A further complication comes with the range of situations that RDI recommendations may pertain to, ranging from normal child development, through moderately malnourished, to the context of high disease loads (such as HIV) and crisis situations. For each of these contexts, nutrition RDIs will vary.

The actual analysis of the Acacia/Moringa kunu is clearly well short of international standards in many respects. Most notable, and most disappointing of these shortfalls were vitamin A (1% of RDI), calcium (16% of RDI), riboflavin (7.5% of RDI) and vitamin C (7% of RDI). The first point that needs to be made regarding these nutritional shortfalls is that a child of 6-8 months old should still be receiving breastmilk, and ideally, a portion of the solids introduced to a child's diet from 6 months of age should include foods of animal origin. The responsibility of all humanitarian agencies involved in child nutrition to promote these key points must not be overlooked.

The very low levels of vitamin A in the Acacia/Moringa kunu was surprising given the reported high levels of vitamin A and retinol in Moringa leaf. The 3 percent Moringa leaf content of the kunu should theoretically have yielded 50.4 µg of vitamin A, (or 12% of RDI for a 6-8 month infant), however the analysis reported less than 5µg (<1% of RDI), of vitamin A. It seems likely that the principal cause of the discrepancy is the use of poor quality Moringa leaf powder in the mix, which has perhaps been dried in the sun or substituted with low nutrition (non-Moringa) plant materials. It will be essential that such quality issues be addressed in the future. It would also be highly desirable that food colour sensitivities be overcome and Moringa content of the kunu be elevated to at least 6 percent to deliver a substantial portion of vitamin A. Increased Moringa content will also elevate levels of iron and calcium to good effect.

Comparing Acacia-Moringa kunu with millet kunu

The Acacia/Moringa kunu is superior to the pure millet kunu in all respects except carbohydrate content. In the case of protein content, the overall protein levels of the Acacia/Moringa kunu are superior, but so too is the balance of amino acids, so that a much greater proportion of the protein content can be used by the body. Whilst the millet kunu appears to offer 79 percent of daily protein requirements, the shortage of the essential amino-acid lysine limits the overall usability of the protein to well below that figure. By contrast, the good range of essential amino acids contained in the Acacia/Moringa kunu (see Table 5) means that most if not all of the protein can be utilised.

Other significant improvements are evident in terms of energy and fat content, up by 9 percent and 29 percent of RDI respectively. Adequate energy is of critical importance since in case of chronic energy shortfall, an infant's body will begin to burn proteins for energy, leading to protein deficiency,

wasting and stunting. Significant improvements are also evident in the Acacia/Moringa kunu in terms of micro-nutrients, especially iron (+57%), calcium (+14%), zinc (+19%) and potassium (+38%).

Likely changes to the recipe arising from the analysis

The Acacia/Moringa kunu recipe would benefit from the following changes:

- Increased Moringa leaf content - to 6 percent, to increase vitamin A, iron and calcium content.
- Increasing Moringa leaf content will allow the removal or reduction of sesame seed (reducing cost) whilst increasing calcium content.
- Removal of Baobab fruit pulp – vitamin C levels are too low to warrant the additional expense, and in any case, much of the vitamin C will be lost in cooking.

Initial trialling

After a few bowls of porridge, when consensus was reached on the 'final' recipe, the group were keen to take samples home for taste testing on their own and neighbour's children. It seemed that the development of the product had become a major community talking point around the homes of each of the group, and a great clamour had arisen for a taste of this new kunu. Fifty packets of 400g each were duly produced and taken home. The kunu mix was fed to husbands, children and babies. The kunu development group were asked to follow up all tasters (or their mothers) with a set of questions that included:

- Did the taster like the flavour/appearance/texture of the kunu?
- Were there any ill-effects from eating the kunu (eg. diarrhoea, stomach discomfort, etc)?
- Were the tasters satisfied after eating the kunu?

I had little control over which questions were asked, or how they were asked, and so no useful statistical analysis is possible from this small and informal taste test, except to say that the reception seems to have been close to 100 percent enthusiastically positive. The one exception was an Australian SIM missionary who thought the mix 'too gritty'. Husbands asked for more, enjoying the 'strength' the kunu gave them, whilst mothers reported that their babies 'slept through the night', instead of waking up hungry.

Perhaps the best measure of the endorsement that the kunu received was that the group decided to begin commercial production of the kunu as a micro-enterprise immediately. One member of the group, Hadiza, was already running a successful small food producing business (cakes) and so was quick to see the market potential of the kunu. After discussing the idea, I agreed to loan 40,000 cfa (around AUD$100) to allow the purchase of ingredients and equipment, and the first batch was being sold a few days later at a SIM acacia promotion event. SIM has made a suitable shed space available, and a SIM worker agreed to support the enterprise with small business training.

The kunu enterprise remains small, with most sales being from the 'compound door', but other outlets include the maternal and child nutrition program at the Danja Leprosy Hospital, retail outlets across Maradi, and 'off the back of the truck' sales as SIM workers make their routine village visits.

Acacia based foods have received very high acceptance in Nigerien villages.

Photo credit: Peter Cunningham

Applicability of findings

The Acacia-Moringa kunu

As exciting as the wholehearted adoption of the acacia kunu concept by the research team was, the resulting micro-enterprise on its own will do little to reduce child malnutrition in Niger. The production of the acacia kunu at micro-enterprise level is only one part of what is needed, and indeed, micro-enterprise production needs to be replicated widely to ensure widespread availability. I argue that there are three levels at which acacia kunu needs to be promoted:

Tier 1: Village level, wherein the concept and recipe for an acacia/moringa kunu is promoted, as part of a package that provides nutritional education, encourages the planting of acacia and moringa trees, and includes measures to ensure that acacia seed is available to those who wish to buy it.

Tier 2: Urban/regional level, wherein supporting and replicating micro-enterprises will do much to alleviate malnutrition in urban areas.

Tier 3: Institutional level, wherein the further refinement, validation and large scale production of a highly nutritious acacia kunu will allow nutritional support to vulnerable families during dry years, that is comprised mainly from local ingredients.

The strength of these integrated approaches is that they are mutually consistent, in using an essentially everyday food to improve child nutrition. Products such as Plumpy'nut have been very successful in the treatment of clinical malnutrition, particularly by enabling treatment to take place in the home through Community Based Therapeutic Care (Cooper, 2009, ValidInternational, 2008). It does not follow, however, as is claimed by MSF, that the next 'logical' step is a blanket feeding program using a nutrient-dense product called Plumpy'Doz (similar to Plumpy'nut but with higher doses of micro-nutrients, recognising the fact that the product is a supplement to normal family foods and not a therapeutic treatment). There is a real risk that such products carry a subtle and incapacitating message to mothers: that they cannot feed their children adequately with everyday foods: that the answer lies outside their world.

The acacia kunu on the other hand offers a model where everyday forms of food are improved – with that improvement driving refinements to the agricultural system – and are employed at several levels in a mutually supporting way. Thus in a good year, a mother might make acacia kunu for household use, using mainly products grown on the family farm. School feeding programs might utilise an acacia kunu mix produced by a local enterprise, and in the inevitable bad year, a very similar product may be distributed to vulnerable families by a humanitarian agency to prevent malnutrition. Meanwhile, all levels of consumption directly support local agricultural production and rural livelihoods, thus strengthening other aspects of nutrition and health.

Acacia-Moringa kunu for rural villages

Realisation of acacia kunu's potential to reduce child malnutrition lies in promoting the idea to rural women. In general, women in Niger put more effort into their children's welfare than men, as seen in informal surveys which revealed that whereas men opted to sell 80% of their acacia seed and retain 20% for home consumption, women tended to be the opposite (Rinaudo, per comm). The importance of the approach lies not only in the number of children that could be reached thereby, but also in that this would be a fundamentally preventative action, entirely within the means of rural people, that could be expected to improve basic child nutrition levels, especially with regard to children's access to quality protein, fats and vitamin A. In effect, this approach also reduces Niger's dependence on the international community for the most basic human need – food. This approach also empowers women to take an active role in improving the feeding of their children, with a focus on improving current practice and outcomes with available resources. The resulting food would not be perfect in every respect – for example, it remains low in calcium, and so the continuation of breastfeeding should be strongly encouraged until a child is at least 12 months of age. Nevertheless, it addresses a major issue: that levels of malnutrition remain disturbingly high in Niger, even in 'normal' years.

Such an approach would be initially restricted to those villages where acacia seed is already grown and well accepted as food, but in these areas it would be an extremely simple and cheap undertaking. As acacia is further promoted and adopted, and also as its availability in the market grows, so too will the number of potential beneficiaries. An effective delivery package would need to incorporate both agricultural and nutritional elements, with tree seed and silvicultural training provided to farmers, and nutritional training provided to women.

It is important that acacia kunu be promoted as a flexible concept. Our purpose should be to take a set of existing (if flawed) practices, and show how they can be modified slightly in order to produce a better outcome. The objective is not to help mothers produce a perfect food (something that is effectively out of reach of the target population), only a better one. The nutritional education provided needs to emphasize ingredient substitution within categories, according to price and availability, rather than adherence to a strict recipe.

The message needs to be that substitutions are preferable to omissions. If a family has run out of acacia seed, it is better by far to replace it with cowpea or soybean than to leave the pulse out altogether. The preference would be for the ingredient ranked highest in each column that is both available and affordable. A kunu made from only top ranked ingredients will be close to optimum given the range of available foods. A kunu made from ingredients ranked at 2-3 would still be very good, and dramatically better than a kunu made of pearl millet only.

Thus, categories could be laid out as in Table 7, on the following page:

Table 7: An ingredient preference chart for improved child feeding at the village level.

Each column should be included, with the selection made from as high as possible in the column, depending on availability, price etc.

	Grains: 55-70%	Pulses: 15%	Oilseeds 15%	Green leaves: 3-8%	Fruit: 3-7%	Salt 1-2%	Sugar Up to 10%
	Carbo-hydrate, protein	Protein, carbohy-drate	Energy	Micro-nu-trients esp. vitamin A, iron and folic acid	Micro-nu-trients esp. vitamin C	Electrolyte Should be iodised if possible	Energy
First choice	Pearl millet sorghum	Acacia seed	Peanut	Moringa leaf Kale (esp. Ethiopia)	Baobab fruit pulp	Iodised	As available
Second choice	Maize Rice	Cowpea Soybean	Peanut oil	Baobab leaf Cassava leaf Marula leaf (Sclerecarya birrea)	Ziziphus Mauritania fruit	Native salt	As available
Third choice	Cassava (a root crop)			Roselle leaf Sweet po-tato leaf	Marula (Sclerecarya birrea) Date (Phoenix dactylifera)		As available

Potential challenges to implementation

- No formal testing or approval of acacia kunu has occurred, (though all ingredients are already a regular part of the diet).
- The potential for implementation is initially limited to those villages where acacia is currently grown. At the minimum, people must have an awareness of acacia seed as food.
- The potential of the concept is greatly limited by the low availability of acacia seed. Seed needs to be made more available, firstly by encouraging village cereal banks to keep a supply as part of their stock, by encouraging (and if necessary financing) petty traders to keep acacia seed stock for sale to villagers (c.f. Rowlands, 2010), and later by increasing tree numbers.
- This is an initiative that can be expected to yield most of its benefits during the relatively good years, when rural people are able to provide for most of their food needs themselves. It will probably help to some extent in poor years by informing buying choices, so that household food purchases may extend beyond just basic grains, to include other important food groups. There will be years, however, when people have no capacity to feed themselves, and at these times, further support will certainly be needed.

Acacia-Moringa kunu production by micro-enterprise

As should be evident in the above methodology section, the production of acacia kunu within a micro-enterprise was a direct outcome of the research. As at the time of writing, the enterprise group in Maradi have been in production for around nine months. The kunu mix is being marketed under the name “Kunnun gina jiki Vitamin”, or “Kunu that builds the body with vitamins”. For my own part, I would be happier with the name if the Moringa leaf content was higher: nevertheless it is still a big improvement on pearl millet kunu, and is not in any case intended to be the sole food intake of any child.

My initial support for the micro-enterprise production was based on the belief that this would be an effective way of making a better complementary food available in urban areas. Despite the greater range of food available, and the higher average wealth levels in urban areas, malnutrition levels are as high in many of Niger’s towns as they are in rural areas (Cooper, 2009). This may be because towns attract the very poor people who, having lost their livelihoods, are no longer able to live in their own villages . These very poor urban migrants tend to bring with them and replicate the asymmetrical social relationships and detrimental weaning practices that are implicated in rural malnutrition.

To date, the kunu producers are selling small quantities to the urban market through a range of outlets, including ‘compound-door’ sales and through the maternal and child health clinic at the Danja Leprosy Hospital, 30km from Maradi. The majority of sales to date have been to people in rural villages with the assistance of SIM. Agents have been engaged in several villages, who hold a small amount of stock for sale.

The initial pack size was 400g (enough for a child for 4-5 days), and sold for 400 cfa (just under AUD$1). Reports received from Maradi indicate a continued high level of taste acceptability, and a great keenness to buy. I was surprised to find that the producer women regarded the rural population as a key part of their market: I had envisaged that difficulties with transport, and the shortage of cash would preclude these regions. Indeed I felt that teaching rural women to make the kunu for themselves was a better and more sustainable option. Rural interest has persisted however, and the producers have tried to make the product more affordable by reducing the pack size (and therefore price) to reflect the very limited cash availability of rural women.

The micro-enterprise production of acacia/moringa kunu has good potential for expansion and replication into new regions, where it could provide income and independence to entrepreneurial women. Micro-enterprise production utilises and builds on local community assets and capacities, and since most ingredients can be locally produced, it strengthens the local agricultural economy and food production system. The start-up capital required is small, and the entire process is simple and familiar to Hausa women, using widely available technologies. An investment in labour saving technology may improve production quality and efficiency, but because labour costs are so low there may be little pay-off in terms of lower prices. The almost complete lack of access to electricity in rural areas also limits the case for technological investment.

Expanding micro-enterprise production of acacia/moringa kunu would help to create an immediate market for acacia seed that is highly visible to the potential growers – the farmers – and thus should strongly encourage increased plantings. This mode of production can be undertaken very quickly and at very little cost. It is thus a viable way of improving the availability of improved foods without the time-lag of waiting for formal production to start. Importantly though, the major limiting factor for this mode of production over the next several years will be acacia seed availability. The approach is also limited by the need for widespread replication. The production potential of each enterprise will be limited by labour availability and distribution reach, and so many enterprises would be needed, each requiring investment, and each needing to be built around the right set of assets: women, buildings, training opportunities and markets. Widespread replication could however potentially lead to problems with quality and consistency of the product. It may be necessary that micro-enterprise production be operated on a franchise basis, with producers offered start-up capital and technical assistance, but are also subject to quality assurance standards and procedures.

Discussions with the kunu producers in June 2010 raised the prospect of a diversification of the business to embrace the supply of processed acacia seed ‘Garin Dan Tahoua’. This followed an interview wherein one of the village agents indicated that “a proportion” of the kunu sold is consumed by men, who value the lasting feeling of satisfaction is gives them as they work in the fields. If the men value the ability of acacia to reduce the pangs of hunger, then it may be possible that simply increasing the availability of acacia, without increasing the workload of women, may be an effective way of boosting consumption in families and of rapidly creating a market. Garin Dan Tahoua will therefore be trialled for sale within the SIM village network during the second half of 2010.

Challenges in micro-enterprise production

During a return visit to Maradi in June 2010, I followed up on the experiences of the kunu producers in some depth. Whilst all rhetoric pointed to a successful enterprise, the reality that emerged was that only 50kg of acacia seed had been used, which translated to a mere 650 X 300g bags of kunu over the nine months: sales equivalent to approximately AUD$430. This is not a volume of production and sales that is going to make any difference to child nutrition, create an acacia market or indeed provide anyone with a livelihood! Hadiza and Mariama reported a number of reasons for the slow development of the business, which included:

- A lack of time. Both of the key women have families and other sources of income that take up a lot of their time. In an environment such as that in Niger, livelihood diversity and risk minimisation are sensible strategies, and neither of the women involved were willing to forego the employment/income-generating activities they have for an unproven business.
- Shortage of working capital.
- A lack of confidence in the product. Though all the ingredients of the kunu are well-known, there is a reticence about promoting it, since it is unproven and untested. The maker’s confidence in the product was not bolstered by the constant talk of ‘needing to test’ for larger scale production.
- A lack of marketing expertise. Neither of the women had a clear sense of where their best market opportunities lay. Advice and subsequent assistance from SIM pushed them towards the rural villages, whilst the potential of the urban market was virtually ignored.
- Logistical blockages. With major market outlets being accessed with assistance from SIM (travel in rural areas is difficult and expensive), problems have occurred with regard to cash flow. Even obtaining a new bag of Acacia seed needed the cooperation of SIM staff, for whom this was not ‘core business’ and was thus liable to be pushed to the bottom of the list.
- Technical and capital. The business can operate at a very low level of technology quite successfully as long as sales remain at a low level and remain predominantly informal in nature. There would come a time, however, in its expansion when a substantial investment would be required. Equipment such as a dedicated mill, sieving machine and bagging equipment would improve efficiency and quality assurance dramatically. There would also come a time in the expansion of the business – such as when institutional customers take an interest – when premises suited to food handling would become essential. The efficient use of capital is also very important, and this essentially means being able to purchase ingredients at harvest time when prices are at their lowest, and store these until they are needed.

Formal production of acacia-moringa kunu

The third tier of an effort to expand the use of acacia/moringa kunu would involve the formal production of the mix, at quantities sufficient to impact malnutrition across a significant portion of a population. Production would need to be sponsored by an NGO which has a role in food aid distribution or child health, and would suit particularly an organisation with a strong region-based focus, such as WVN. A kunu produced in this way should be seen primarily as a preventative food, and targeted, through early identification and intervention, to vulnerable families with small children, aged between six months and five years. Product distribution could be through health clinics – where records of children's nutritional status are also kept – or through other regular contact points. It should not be seen as a therapeutic food: Plumpy'nut already serves this purpose and its efficacy has been extensively documented. It is, however, a real alternative to Plumpy'Doz , and one that is entirely consistent with local cuisine and could contribute much more to local livelihoods, since all main ingredients are purchased locally. For distribution under the aegis of humanitarian agencies it would be necessary to adjust the kunu formulation for optimal nutrition: for this application, merely 'better' is not good enough. The food needs to be as close to perfect as any single food can be. The product would still be based as far as possible on local ingredients, but additional nutrient components would need to be imported. Based on the analysis of the first recipe, this would include vitamin A, zinc, calcium, iron, and most 'B' group vitamins as a minimum. Formal testing would also be required to ascertain safety, palatability and the effectiveness of the product in maintaining good growth in non-malnourished children.

The tests required are:

- A full nutritional analysis, with adjustments to the formula and subsequent retesting (see table 5).
- A 'cross-over' design acceptability trial, to demonstrate the relative taste acceptability of the kunu compared to one or more alternatives (such as CSB++).
- A randomised control trial to ascertain the effectiveness of the kunu in assisting children to maintain health and normal growth.

This testing would be conducted on normal, healthy children. The NGO Valid International would be an appropriate body to undertake these tests.

Despite the clear potential of this approach, the formal production (or indeed micro-enterprise production) of acacia kunu or any other complementary food does carry risks. Mothers may be led to believe that the processed product is superior (as in truth, it would need to be), and divert scarce household cash toward obtaining a product that they can prepare themselves. Palmer writes: "If elite mothers in any community buy and use industrially processed complementary foods this creates a two tier food system and motivates poor mothers to buy such foods. The marketing of these foods exploits parental aspirations, exaggerates the nutritional benefits of the foods and obliterates impartial messages about locally available foods". A further concern is that an enterprise successfully undertaking industrial production and marketing of a complementary food will be a prime target for a takeover by multinational food producing companies, raising the risk of further loss of local control over the food supply system to an entity primarily motivated by profit (Palmer, 2009; 36).

The major challenge facing a plan to produce acacia/moringa kunu at a large scale will be in scaling-up acacia seed production to the required levels. As at the 2009 harvest, only about 1300kg was available for purchase. This low figure partially reflects poor rainfall in the 2008 rainy season (50 percent of the 30 year average), but more importantly attests to disappointing adoption rates that can probably be attributed to the lack of a functioning market for the seed (Rowlands, 2010). Most households that were involved in acacia production reported that they ate at least some of the seed that they produced, and Rowlands (2010) estimates that domestic consumption may account for around 31 percent of the seed crop (see also Cunningham and Abasse, 2005). This high level of acceptance is undoubtedly good news for family nutrition, however it makes the scale-up task somewhat harder.

Formal production is very cost sensitive, and economies of scale are likely to dictate that production in the order of 100 tonnes of kunu per annum is required (Dibari, P., Pers. Comm). To achieve this, around 20 tonnes of acacia seed would be required in addition to domestic consumption needs, requiring a dramatic increase in acacia production levels. Once the product is established, the resulting acacia seed market can be expected to greatly stimulate the planting of acacias on farms, however there will be a need to actively promote the initial expansion in plantings . This amounts to a significant investment, though it is entirely consistent with the livelihood and food security objectives of organisations such as World Vision (and indeed such programs have been in place for several years). Acacias will produce their first seed crop after only 18 months if conditions are favourable, however there are tight timing considerations for tree planting, that dictate the beginning of a planting cycle, and a need for farmer training to support the expansion, so that a realistic timeframe for formal production would be 3-4 years.

The potential of the food aid market

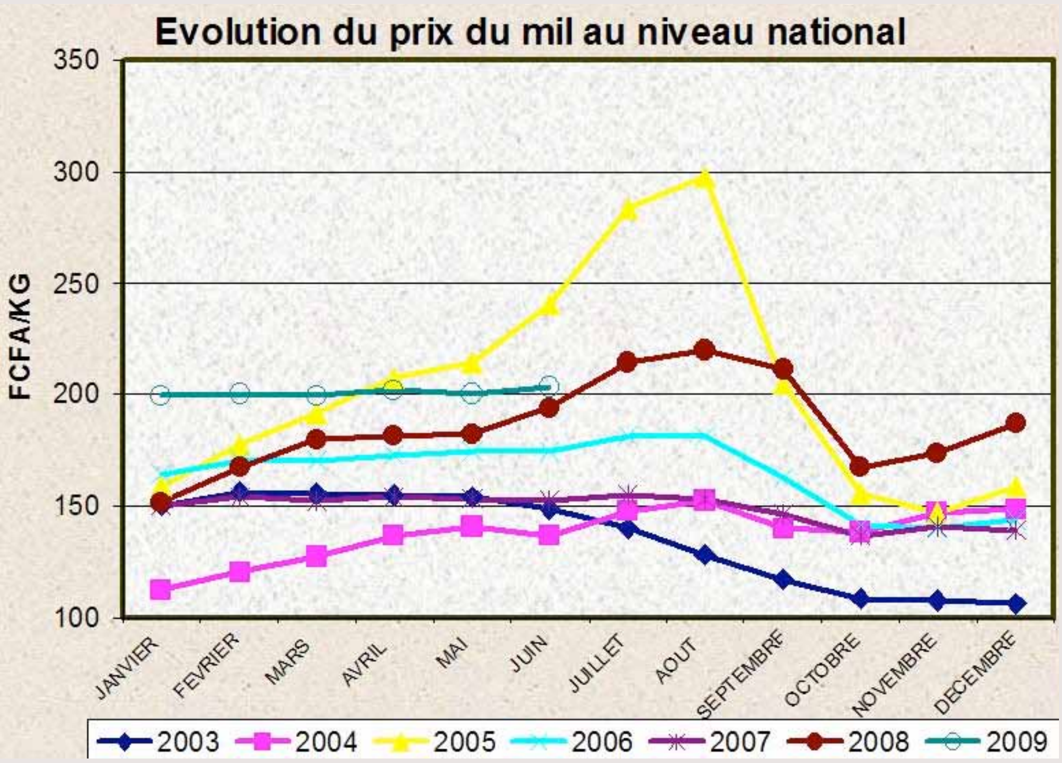
The potential of the food aid 'market' is clear. The UN WFP Regional Bureau for West Africa expects to provide assistance to over twelve million beneficiaries in 2010, with a total budget allocation of US$494.9 million. Total distributions of 418884 metric tonnes are planned for 2010, with 86478 metric tonnes – just over twenty percent of the total – being 'blended foods'. Even were a tiny proportion of this amount spent on acacia, the benefits to farmers could be significant, with a major stimulus to tree planting that would generate multiple income streams and build resilience. The funds furthermore would tend to cycle multiple times through the local economy increasing income potential and reducing poverty. Through projects such as this, food aid can be so much more than a 'band-aid' solution: it has the potential to be transformative.

Internationally funded food aid has taken many forms across Africa over the past five decades. Some approaches to the procurement and distribution of food have been strongly criticised for the ways in which they fail to deliver the foods that are needed in a timely fashion, or for the fact that they may create dependency in recipient populations, or even undermine rural economies and livelihoods, thereby making the advent of famine more likely in the future. It is not the intent of this report to survey trends in food aid policy and practice, and the reader is directed to the excellent analysis of Barrett and Maxwell (2005) for a full understanding of these matters. I do wish, however, to point to some important trends in the ways in which food aid is procured that have emerged in recent years. Firstly, the WFP has attempted to purchase a significant proportion of the food it distributes from within Africa. The success of this policy is hard to ascertain as figures are hard to obtain, but it is also important to note that although a large proportion of food purchases may be made in Africa, the suppliers are overwhelmingly industrial farm enterprises, many located in South Africa or Mozambique, whilst small producers – that is to say, the vast majority of farmers – have little opportunity to participate or benefit (Coulter, 2007). Secondly, a small WFP sub-program called P4P, or 'Purchase for Progress' is attempting to pilot a way in which smaller producers can benefit through food aid production and sales (WFP, 2010). It is also interesting to note the March 31st 2010 announcement of the European Union that "Handing out cash or vouchers for food, or buying food aid in or near the country in need of emergency food assistance, has become official policy" (IRIN, 2010a, emphasis added). This acacia research is entirely consistent with this latter approach, and seeks to harness the economic opportunity of food aid as a transformative force for rural communities in the most marginal areas.

Ingredient availability and price

The availability and price of the various ingredients will impact strongly on the viability of the acacia/moringa kunu. Pearl millet, peanut and sugar are commodities that are well established in the market. Price fluctuations for pearl millet for the period 2004 – 2009 are presented in Figure 2. Acacia seed, moringa leaf and baobab fruit pulp are relative newcomers to the market, or are traded in very small quantities, so that market information is difficult to obtain and unreliable. These products will be discussed in turn below.

Figure 2: Millet price fluctuations, Niger 2003-2009.



Moringa

Information supplied by Tougiani Abasse of INRAN indicates that commercial production of Moringa is well advanced in Niger, with significant areas planted in the Niamey region, especially where irrigation is available. There would be little difficulty in filling orders of even several tonnes so long as sufficient lead time is given (Abasse, per comm.) It would be essential however, to specify shade drying of the leaf in order to minimise nutritional losses incurred in processing (Price, 2007). A minimum production run of 100 tonnes of kunu would require around 3-5 tonnes of dried, crushed Moringa leaf. Dried, ground Moringa leaf ranges in price between 200 cfa and 400 cfa (AUD$0.40-85) per kilogram depending on seasonal factors. Contracting Moringa production will almost certainly stabilise prices, whilst assuring quality at the same time.

Moringa is also being actively promoted by many NGOs in Niger as a household tree. Increasing availability at the household level can be expected to yield significant nutritional benefits, especially to children. The demand for seed is high and ICRISAT has large areas dedicated to the replication of seed for both M. oleifera (PKM1), and M. stenopetala.

Moringa leaves for sale in local market, Southern Ethiopia. Moringa is already a highly sought after and accepted food in many African countries.

Credit: Tony Rinaudo

Pearl millet

Pearl millet is widely grown, and is available in markets, both large and small. Harvest is in November, and it is at this time that prices are at their lowest. The purchase of pearl millet for inclusion in an acacia/moringa kunu would need to balance the following considerations:

- A minimum production run of 100 tonnes of kunu would require 55-60 tonnes of pearl millet.
- The productivity of the harvest. What quantity of product is excess to local requirements?
- Are there important semi-institutional markets such as cereal banks that could be adversely impacted by purchases?
- What quantities to farmers need to sell?
- Is the objective to obtain cereal at the lowest price, or to pay a fair price?
- Is it preferable to purchase from individual farmers, or will this incur excessive transaction costs?
- A large proportion of Niger's cereals are imported, and the pearl millet available in the larger markets is likely to originate in Nigeria or Burkina Faso. Is this consistent with the desire to utilise local products as far as possible?

Peanut

Peanut is an important cash crop in the Maradi region of Niger, and peanuts are easily obtained in both large and small markets. Procurement protocols would need to be developed to minimise the presence of harmful aflatoxins. A large volume of peanuts are crushed for oil at a plant in Maradi. A minimum production run of 100 tonnes of kunu would require around 15 tonnes of peanuts. Peanut prices in Niger vary considerably according to quality and season with a likely range between AUD$500-1200/tonne.

Baobab fruit pulp

Baobab fruit pulp is produced in significant quantities in Nigeria, Burkina Faso, Mali and Senegal. Baobab are widespread in the wetter areas of Niger, though the trees in that country are generally heavily harvested for their nutritious leaves. If the decision were made to include baobab pulp in the mix, a minimum production run of 100 tonnes of kunu would require 2 tonnes of fruit pulp. This would certainly need to be imported from Nigeria.

Sugar

Sugar is readily available, though it is entirely imported. A minimum production run of 100 tonnes of kunu as currently formulated would require 10 tonnes of sugar. Price range is AUD$350-450/tonne.

Current and future availability of Acacia products

Access to Acacia seed

Acacia trees are not widespread in Niger at this time. It is a crop that is largely restricted to a radius of 40km around the city of Maradi, and is there primarily as a result of the promotional work of SIM over the past two decades, and of World Vision Niger over the past five years. Many villages in the area do not grow acacia and know almost nothing of its benefits. Yet the potential for acacia to improve child, and general, nutrition in Niger (and elsewhere in the Sahel) is of course completely dependent on the seed being available. A very large expansion in acacia production, within agroforestry systems is warranted, and SIM data presented above in Table 2 shows clear livelihood benefits that should result.

There is also a need to mature the economic status of the crop, from its currently rather marginal position of predominantly home use (approx 31%), or else traded in what Rowlands (2010) describes as an 'artificial ' market, into a more 'natural' market distribution system. A natural market could take many forms, from simply redistributing seed from one farmer to another (thus supporting the household use of acacia seed), to the purchase of large amounts of seed for further processing (as in the formal production model). The former example clearly exists to a small degree, as farmers in several villages talked of selling seed to their neighbours, and the latter continues to exist, but is probably not sustainable. In any event, purchasing seed and just storing it removes the seed from the community, where it could be being eaten, traded and, importantly, normalised: people could be becoming more familiar with it. Ultimately, acacia should come to be found in the stocks of petty traders in both rural and urban markets, who would be selling it as food. The objective has to be that acacia is just like any other agricultural crop, in that any grower who has an excess supply of seed can sell it, and anyone who has need of it can buy it if they have the money. It may be possible for WVN to assist small rural traders (of which every village has a few) with start-up capital to stock a small amount of acacia that can be sold in small measures to anyone who wishes to buy it.

Another potentially useful approach is to utilise the network of cereal banks that have been established in many villages in Niger. Community cereal banks have been an effective tool by which rural people can manage the tensions between their seasonal cash and food needs, without recourse to usurious loans. Cereal banks vary widely in terms of their governance and role, with these rules typically being set by the sponsoring NGO, whilst day to day running is placed in the hands of a committee based in the community. Some banks, such as those established by the Red Cross and Red Crescent, are constitutionally restricted to buying and selling pearl millet, and then may only sell in the months of the 'hungry gap '. WVN cereal banks, on the other hand, are free to buy and sell whatever products they feel are appropriate, and can operate at any time of year.

Cereal banks that are less encumbered offer a sound potential element of market infrastructure that could purchase acacia seed from local growers at harvest, store the resource, and sell back to the community as required. Given the nutritional value of the acacia seed, and the value it can add to a diet of pearl millet, there is good reason for cereal banks to participate. These structures also offer potential distribution points for micro-enterprise or formally produced kunu.

Author, Peter Yates, with acacia seed stock.

Credit: Peter Cunningham

Amounts of seed currently produced

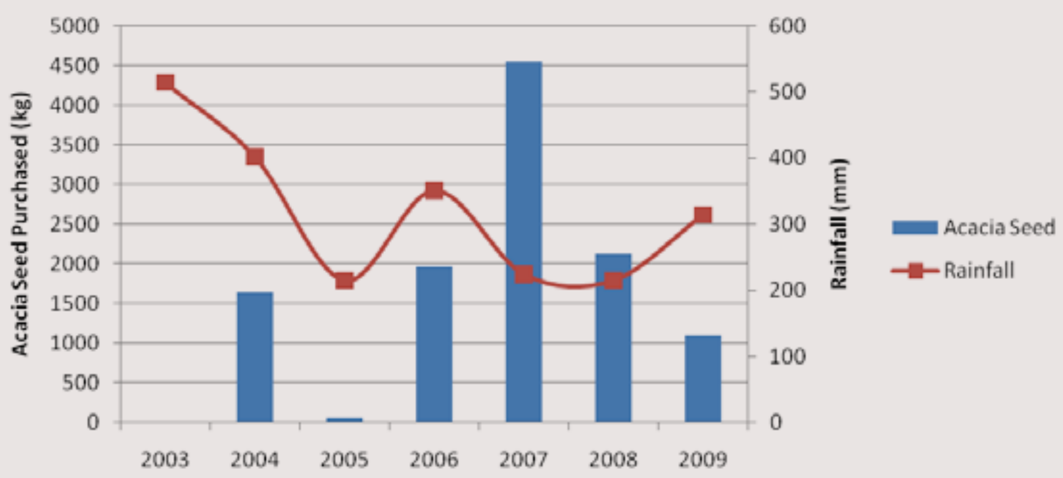
Despite many years of promotion and planting, acacia seed production remains disappointing. Figures collected by Rowlands (2010; 7) for four villages to the north of Maradi indicate that acceptance of the crop remains low. In total, for the four villages, only 2600 trees were reported to have been planted in 2008, and of these around 2000 were estimated to have survived . Assuming maximum recommended planting densities of 100 trees/hectare, this indicates that only 26 hectares out of a possible many thousand were planted to acacia in that year.

There are several possible reasons for this apparent reticence:

- Early acacia plantings were too closely spaced, leading to short tree life-spans and low productivity;
    - Tree management knowledge has only gradually emerged, and many trees died at younger ages than they should have;
    - Until sophisticated agroforestry understandings and practices were developed, competition with annual crops could be severe;
    - Early perceptions that A. colei has a short lifespan have persisted, and Government forestry agents have been actively discouraging the planting of A. colei for this reason (they have also been actively promoting the planting of A. senegal for gum Arabic production, to the exclusion of other species).
- Where significant plantings have been undertaken by some NGOs there has often been a serious lack of follow-up to ensure that proper silvicultural techniques were understood by the growers.
- There has been no 'natural' market for the seed.
- Hausa farmers tend to be very conservative, and try to avoid doing anything that could set them apart from their neighbours for fear of derision or jealousy; and
- Staff changes at SIM, who have been the primary organisation promoting acacias, led to changes in program emphasis, and some neglect of the acacia program at times.
- Farmers choosing to grow acacias are more risk taking 'early-adopters' (Rogers, 1983). More cautious farmers are waiting for encouragement before taking any risks.
- Acacias have not been promoted in all villages.
- Seedling availability in villages is limited. SIM policy has been that seedlings should be grown and tended by a volunteer in each village. Success has therefore been understandably patchy.
- Years of poor rainfall have limited both seedling survival and seed production by mature trees, thus undermining motivation.
- Though the acacia seed harvest does not compete for labour with the agricultural calendar, it does compete with the 'exodus', and there may in fact be a shortage of labour to harvest the seed, especially in dry years where more men have migrated in search of work .

Acacia seed production is strongly influenced by rainfall as is shown in Figure 3 below. Given a modest but steady increase in tree numbers, the seed available should display a steady increase from 2005 onwards . Instead, it is evident that the harvest is seriously diminished when precipitation from the preceding rainy season falls below 350mm. It is thus critical that acacia species and provenances be found that are able to seed reliably in low rainfall years. It is feasible that desert adapted species could yield well with as little as 200mm/annum rainfall.

Figure 3: Acacia seed purchases compared to rainfall, 2003-2009.



Scale-up of Acacia production in Niger

Acacia plantings in Niger have been increasing fitfully for the past 15 years. If any widespread benefit is to be achieved from acacia in Niger, a rapid and widespread scale-up of plantings is required. Successful implementation will be dependent on an effective campaign that can provide the best genetic material, deliver the necessary resources at the village level, and provide effective and on-going training in acacia cultivation and its preparation as food. It is important that extension efforts create an enabling environment, integrating issues such as markets and market access; economic viability compared to the alternatives; viable and known production technology; security of land tenure, and; ability of farmers to control risks (Woods and Petheram, 2001).

The seed amounts needed for each element in this kunu proposal are very difficult to calculate (how long is a piece of string?) In the case of household use, it is difficult to imagine acacia being available for use in children's food and not being used for general family consumption as well, therefore a per family estimate is as follows:

- In a plentiful season, a typical family of 8 people (6 children) will consume 5.4kg of pearl millet per day (delivers an average of 10680kJ per person).
- Replacing 20 percent of this pearl millet with acacia (with approximately 30 percent of the initial weight removed as bran) would require 1.4kg of acacia.
- Multiplied by 356 days, this means an annual requirement for a typical household of 511kg.
- Assuming reasonable seasons and good management, at the minimum expected harvest (1kg/tree) this amount could be supplied by around 500 trees. This could be achieved within an agroforestry system, along with pearl millet and cash crop production, on 5 hectares of land.

For micro-enterprise production, the acacia need is much more difficult to estimate, since factors of market size, consumer's ability to pay and the time available to the producers will all influence the production of any one enterprise. Then the estimate needs to take into account the number of production enterprises that are created. In Maradi, a good living for 2-3 people making acacia kunu could be achieved by using 2-4 tonnes of acacia seed per year.

Formal production of acacia kunu would require a minimum of 20 tonnes of seed per annum, requiring around 20,000 trees, on 200ha of land. This seed requirement could be purchased from small farmers, from their household excess. Another, possibly more reliable approach would be to establish acacia plantations on degraded lands, offering training and material support to disadvantaged groups, who ultimately gain ownership over the productive resource.

Scale-up of Acacia production using degraded lands

One of the great values of the Australian acacias is that they will thrive even on very poor land, and restore its soil condition over time. In some regions of Niger (Tahoua and Illéla), up to 50% of the arable land is severely degraded; in the Maradi region, the proportion is smaller, though vast areas of scalded, weed infested lands are to be found. Some of these land areas could potentially be made available for acacia production. A basic model for this has been developed by ICRISAT, with their 'Bio-reclamation of degraded lands' concept (Pasternak et al., 2009). The concept has the potential to assist particularly disempowered groups (such as women), by helping them to obtain a productive asset, produce a cash crop, and grow a better range of foods for the family.

The success of such an approach is entirely dependent upon the successful negotiation of issues of land tenure and ongoing management. Ownership and responsibility for land and trees must

'Hard pan', laterite site. Millions of hectares of land in Africa have become degraded to the point of being unusable, however suitable Australian acacias make excellent pioneer species which can assist in the restoration process, producing firewood and edible seed and providing shelter in the process.

Credit: Tony Rinaudo.

be absolutely clear or the project will not be sustainable: young trees will not be protected from livestock, whilst older trees will be subject to uncontrolled cutting. There is, furthermore, a very real potential for serious conflict if the perception arises that pastoral lands – which make up the majority of the severely degraded lands – are being taken over by settled, agricultural groups.

Accessing degraded lands

Access to degraded land in Niger can be obtained by application to the Government. I was told that it lies within the remit of the Regional Director of the Environment to allocate lands (Aboubacar, K. Pers. Comm.). The Regional Director has the power furthermore, to impose restrictions on grazing as required, though given the low levels of resourcing, the ability to monitor and police such arrangements is doubtful. Upon application, negotiations will be joined by the various stakeholders including the Department of Environment, the local 'chief' and the headmen of the surrounding villages, as well as the 'chief' of the relevant Fulbé (Fulani) pastoral community.

Consideration should be given to the possibility of involving the Fulbé in acacia production. Such an approach may involve some challenges around management continuity and tree protection, due to the transhumant nature of many Fulbé groups, but this must be viewed against the reality that a large proportion of degraded land is notionally (at least) 'pastoral', and that amelioration of these lands will require the engagement and participation of the pastoral stakeholders. Simply transferring ownership or control to settled peoples will create the potential for conflict and will only further concentrate grazing onto the remaining pastoral lands, with serious implications for both livelihoods and sustainability.

In an interview with the Regional Director for the Environment in Maradi, Mr Kossoukoye Aboubacar, I was told that the Government was implementing a policy between 2010 and 2012 designed to reduce the amount of degraded land in the Maradi region to 10 percent of the total land area . The program involves building 'banquettes' and/or 'demi-lunes' for water capture, and the wide scale planting of trees – principally Acacia senegal with a view to building livelihoods through gum Arabic production. Mr Aboubacar was supportive of use of Australian acacias however, due to the support they can give to food security, another major concern of the Government. The program mobilises labour through a 'Cash-for-Work ' arrangement that has been given additional impetus by the famine conditions of 2010.

An outline of a degraded lands Acacia system

The predominant tree in the degraded land system should be acacia, at around 70 percent, however there are many other species that could and should be planted to increase diversity and add valuable dietary variety. These should definitely include Moringa stenopetala or M. oleifera, Ziziphus mauritania (Pomme de Sahel – a high value fruit, also rich in vitamin C), Adansonia digitata (Baobab – mainly for its leaves) and Sclerocarya birrea (marula – a sweet and tasty fruit, with edible leaves and nut). Between the trees, zai-holes (small compost pits filled with manure or other organic material for growing specific trees or vegetables), should be dug. These can be planted with cash generating crops such as sesame, okra, tomatoes or melons.

Thus in the first year, income will be from the annual plantings only. By the second year, a small crop of acacia seed should be harvested, along with the annual crops and a small cut of firewood. Zai-holes will need to be re-dug and manured every second year.

A system such as this has potential to find financial support on the basis of its value as adaptation to climate change, though there are other very real values pertaining to food security, agricultural training, women's empowerment and of course, family and child nutrition.

For reasons that are not entirely clear, acacia seed adoption and production has been disappointing to date. It may therefore be advisable to conduct a set of pilot projects prior to making a large investment, in order to ascertain the real levels of commitment that can be expected from participants, and the levels of production that can be realistically expected under such conditions. Pilot projects conceived with the intention of producing 25-30 tonnes of seed would not be prohibitively expensive, would provide a powerful impetus to other growers, and would give sufficient seed to enable all levels of the proposal to be implemented.

The key steps to realisation would be:

1. Identify funding.
2. Identify potential lands, paying attention to:
    a. Land tenure;
    b. Who may hold usufruct rights, however small the harvest or grazing benefit might be. Can these rights be successfully negotiated?;
    c. Whether a secure lease arrangement can be negotiated on a portion of the identified land. Does the village headman have the necessary authority?
3. Identify potential project participants/beneficiaries
    a. Identify target group(s), eg. Women, young men, other.
    b. Form intended participants into a community association capable of holding a lease and allocating land portions to participants.
4. Negotiate a lease with the appropriate authority
    a. Register this lease as is appropriate with the Niger Government, Ministry for the Environment.
    b. Allocate portions of ½ hectare and upward.
5. Establish a tree pépinière in a nearby village – contract the nurseryman to produce the required number of acacia trees. Additional tree species might need to be brought in from elsewhere.
6. Use Food-for-Work or Cash-for-Work funds to mobilise labour for the preparation and planting of the land potions. This would involve:
    a. Marking out portions clearly;
    b. Existing trees, shrubs and ground cover species should be retained and encouraged;
    c. Digging 'demi-lunes' – half-moon shaped pits that concentrate water for trees;
    d. Digging and planting zai-holes;
    e. Planting of acacia and other trees early in the rainy season;
    f. Weeding around young trees.
7. Concurrent with ground preparation and planting there is a need for training in how to grow, maintain and use the range of species that are planted.

Issues with Intellectual Property (IP)

This research was completed with the support of World Vision Australia, and as the major sponsor, that organisation holds the Intellectual Property rights associated with the resulting food product(s).

It is important to note the following however:

- The Maradi women who worked on this project need to be considered as holding a degree of IP ownership over the kunu. They have developed a trade in the product, albeit small, and would need at the very least a ‘right to negotiate’ with World Vision regarding any plans to move to large scale production.
- The full realisation of the vision contained in this report will require further investment in product refinement (to maximise nutrition), Acacia seed production and product manufacture.
- The full realisation of the vision will also require the collaboration of organisations with specific expertise, such as Valid International.
- A final version of a commercial product would be substantially different to the prototype.
- The major benefit to poor rural communities will come from the promotion of an Acacia kunu recipe that can be produced by mothers in villages. A widespread adoption of the kunu (and of course, acacias) would be powerfully preventative of child malnutrition. This needs, therefore, to be seen as core to World Vision’s values and work.

Australian Acacias in Ethiopia

The potential of Australian Acacias to make an important contribution to rural livelihoods is not restricted to Niger or the Sahel. Many species of Australian acacias have been introduced successfully into Africa , including A. saligna, which originates in Western Australia, and which has been planted by the Tigraian Forestry Department for over twenty years in the arid mountains of Tigrai to reduce soil erosion.

Rainfall in Tigrai is highly seasonal, with most precipitation falling in the June-August rainy season, with virtually no precipitation for the remainder of the year. The rocky mountain slopes are generally bare of trees, and most farmers, cultivating the relatively flat valley floors below, expect to grow only enough food to supply their families for a quarter of each year.

The mountainsides of Tigrai were once covered with Juniper-Olea afromontane forest (Friis, 1992). Today, outside of National Parks, the only remnants of these forests are found adjacent to churches where religious sentiment provided some protection. With deforestation on this scale, coupled with the heavy falls typical of monsoonal rains, the runoff of water following a rain event has become rapid and violent, resulting in severe soil erosion and gully development. The rapid movement of water across the landscape has also greatly reduced the opportunity for water to infiltrate the soil, resulting in a lowering of water tables and drying of watercourses and wells, with serious implications for local livelihoods.

Many years of rapid population growth has led to a serious shortage of arable land in Tigrai. In a study of one village, Beyene et al (2006) found the average land holding to be 0.39 ha, with a range of 0.05-0.94ha, with the average family holding three plots. Rinaudo and Admasu (2009) report similar figures, with household land holdings of between 0.25-0.5 hectares, whilst approximately 30 percent of the population do not own land, and may need to rent the land they cultivate. Part of the land shortage problem in Tigrai stems from the fact that fully 50% of the land is too steep to farm, and since deforestation, contributes little to livelihoods other than poor quality (and often illegal) grazing.

The Tigraian Government has undertaken a land rehabilitation program of massive proportions , building terraces, and digging bunds, soakage pits and channel diversions across hundreds of square kilometres of the region. Slowing the flow of water has reduced gully erosion, reduced the turbidity of streams and raised water tables in the arable valley floors to levels that be reached by hand-dug wells and used to irrigate crops of citrus, guava, tomatoes, chillies and capsicums. These earthworks do not only offer potential for agricultural improvement on the flat valley floors, but provide the basis for future tree crop agriculture that has the potential to almost double the productive land area, to provide food, wood, fibre, fodder, medicinal plants and bee forage. Adding to these efforts, some areas have been closed to grazing, in order to encourage forest regeneration, whilst literally millions of A. saligna have been planted to help stabilise soil on the steep slopes.

I was told by a farmer in the village of Womberta Emba that the planting of A. saligna was at first met with scepticism by rural people, who regarded this foreign tree as “a home for evil”, liking neither its dark foliage or its unfamiliar form. With more than a decade of experience to draw on however, in which time people came to understand better what the species has to offer in terms of fuelwood, fodder and erosion control, A. saligna is now regarded as the “second most important tree” in the landscape (after Olea europa africana). On top of the benefits currently recognised by

Traditional 'injera' flat bread made from 25% Acacia saligna and 75% teff grain.

Credit: Tony Rinaudo.

farmers, A. saligna offers a tremendous opportunity to boost food production, since it produces excellent crops of edible and nutritious seed. Indeed, for over a decade, A. saligna trees have been producing heavy crops of seed, in November-December each year. These have been left to fall to the ground, or to be eaten by birds and monkeys, even as the people are hungry and dependent on food aid for the majority of their needs. This loss occurs simply because people do not know that the acacia seed is edible, nor of course how to prepare it. Just how much food is lost in this way each year is impossible to judge, however there is no doubt that in 2009, some thousands of tonnes of high protein seed fell to the ground and was lost across Tigrai . This lost acacia seed could have been a valuable complement to the wheat that is produced locally or distributed as food aid, just as it complements the pearl millet dominated diet of Niger.

The potential of the seed of A. saligna to reduce child malnutrition is as strong in Tigrai as it is in Niger. In Tigrai, the incidence of child malnutrition is similar to that in Niger, though, broader poverty concerns aside, the underlying causes are different. In Tigrai, children are breast-fed almost exclusively until well past their sixth month, and often into their second year (Gebriel, 2000). The tendency in Tigrai is to delay the introduction of solids into a child's diet, thus child malnutrition in Tigrai tends to arise at the point when a child's energy and protein needs outstrip the supply available to them from their mother's breastmilk (Gebriel, 2000). A heavy dependence on food aid is an important causal factor in child malnutrition in Tigrai. Since most food aid is delivered as a single product – usually wheat – households, including young children, often survive for long periods on a diet comprising almost exclusively wheat. Meanwhile, as in Niger, a change in the climate has led to less rainfall and to less reliable spacing of rainfall. This has greatly reduced the range of crop options that are available to farmers, and has rendered the diet chronically deficient in fats and therefore energy .

The weaning food most favoured in Tigrai is 'sebqo', a thin porridge traditionally made of wheat or teff. The reality of today's world is that generalised poverty means few rural families can afford to eat much of the best food they produce. Products such as teff, poultry and eggs are usually sold for cash income, whilst young children are raised on a diet of breastmilk and wheat sebqo. Sebqo (whether made from wheat or teff) is like pearl millet, an inadequate weaning food, being low in protein, energy and many micro-nutrients, leaving the diet inadequate, even with the continuation of breastfeeding.

In November 2009, I produced a trial batch of sebqo, at the Tigrai Agricultural Research Institute (TARI) in Mekelle, Ethiopia. The sebqo was made from wheat, acacia saligna seed and linseed. The addition of Moringa leaf would have been desirable, however this could not be procured in the time available. The resulting sebqo was tasted by a gathering of TARI researchers, World Vision staff and a range of other NGO workers from around Mekelle. The response to the tasting was overwhelmingly positive, and aside from the shortage of some micro-nutrients (which would have been improved through the use of Moringa leaf), the product was, in terms of nutrition, a significant improvement on the wheat-only version that most children are offered.

It is certain that the nutritional status of many thousands, and probably millions of people in Tigrai could be dramatically improved if the seed of Acacia saligna can be widely incorporated into diets. An examination – and possibly a rethink – of the land tenure conventions of Tigrai may be necessary to ensure that rural people are able to harvest A. saligna seed legally. An extensive education campaign would also be required to alert villagers to the potential of this very large food resource. A reluctance to adopt new ideas will certainly provide some challenges, yet the outlook is promising, since it has been widely commented that "monkeys eat the seed", and that therefore "it is probably edible for people as well".

A feeding supplement similar to the Nigerien kunu could be quickly and easily developed in the Tigrai region, and the tiered approach advocated for Niger would be entirely appropriate to pilot in Tigrai. Furthermore, the existence of such large plantings of A. saligna means that such a project could be undertaken with none of the scale-up issues that will be faced in Niger.

Beyond seed: Further potentials for Acacias

What would happen if efforts to promote Australian acacias for the value of their wood, seed and shelter were to be successful? I argue without hesitation that farmer income and food security would be greatly improved. Is it not possible however, that the currently buoyant market for building materials and fuelwood could be saturated if acacia production were to take hold at a large scale? It is worthwhile, therefore, to consider how an excess of fuelwood could be absorbed and turned to economic benefit.

I propose that a system could be developed that produces income streams from seed, fuelwood and charcoal, energy and the sequestration of carbon. Such a system could, furthermore, attract expansion funding as an 'adaptation to climate change' activity. See Joseph (2009) for a detailed framework and methodology by which small scale biochar systems could benefit communities in the developing world.

The technology is now well developed by which wood and other biomass can be efficiently burned to yield electricity, with biochar as a major by-product (Lehmann and Joseph, 2009). The value of electricity is clear enough in a rapidly growing country where the supply is expensive and unreliable. The value of biochar requires some elucidation.

What is biochar?

Biochar is charcoal that comes from sustainable, natural sources. According to Lehmann and Joseph, "…biochar is the carbon-rich product obtained when biomass such as wood, manure or leaves, is heated in a closed container with little or no available air" (2009; 1). Biochar can be made from crop wastes, manure or from purpose-grown woody material. The value of biochar is twofold: firstly, it has highly beneficial effects when added to soil, and secondly, it is a substance that stores carbon in a relatively stable way. The process by which biochar is made can, furthermore, yield carbon-neutral or even carbon-negative energy.

Added to soil, biochar helps to improve moisture retention, reduces nutrient leaching (Major et al., 2009), reduces the release of non-CO_2 greenhouse gases (Van Zwieten et al., 2009), increases bioavailability of many nutrients including nitrogen and phosphorus (DeLuca et al., 2009), and provides habitat for many beneficial soil micro-organisms (Thies and Rillig, 2009). The carbon stored in biochar breaks down very slowly, even when added to soil where other material of biological origin would rot. Actual residence times of the carbon in biochar are dependent on soil type and climate, and are subject to ongoing investigation, however charcoal particles (essentially the same as biochar) have been found in many old forests that date to several thousand years old (Lehmann et al., 2009). This long residence time means that biochar has the potential to be a significant and effective way of sequestering carbon dioxide (CO_2), and thus opens the possibility of African farmers participating in the carbon trade. Whereas the storage of carbon in living trees is difficult to measure and verify, and is of highly tenuous security (forests can be cut and burned), biochar stored in soil is stable, secure and should be easily and reliably measured once appropriate protocols have been approved (Manning and Lopez-Capel, 2009).

Components of an energy-biochar system for the Sahel

The implementation of a viable energy/biochar system in the Sahel would need to be based on significant new plantings of Australian acacias. Acacias can be grown in an agroforestry system, either on existing farms or on degraded land, with a positive benefit to cereal production. Crop wastes are significant across the region, but these should not be used for biochar as they are in heavy demand for dry season stock feed and building, and what is not thus consumed has an invaluable role to play as mulch, protecting the soil from sun and wind.

Funding

Funding to cover the cost of implementation should be readily available from international sources since the outlined project strongly meets the objective of 'adaptation the climate change', that was endorsed by the 2010 Copenhagen Agreement.

The proposed project aids in adaptation to climate change in the following ways:

- By diversifying agricultural systems toward drought tolerant perennial plants;
- By improving livelihoods and food security at both farm and regional levels;
- By reclaiming degraded lands for food and income production;
- By increasing tree cover, potentially across wide areas;
- By improving soil health including water and nutrient holding capacity; and
- By targeting vulnerable groups for interventions;

The proposed project also contributes strongly to mitigation of climate change by:

- Increasing the supply of renewable energy; and
- Sequestering a durable form of carbon in soils, and thus offsetting atmospheric CO_2.

Management

Acacias can be grown on family farms as part of an agroforestry system, or they can be grown very successfully on degraded lands as part of a larger community mobilisation program. A more detailed outline of how the planting of degraded land can proceed is provided on pages 72-73, above.

A trading company or association would need to be established to manage the purchase of feedstock, to operate the electricity/biochar producing equipment and to manage sales of electricity. Further possible functions would be to manage the return of biochar to wood producers, to measure and verify soil carbon increases, and to channel carbon funds between the global carbon markets and the people on whose land the carbon is being sequestered.

It would be highly desirable that the feedstock producers – the small farmers – have a stake in the ownership and management of this trading entity.

Technology

The technology to convert woody feedstock to electricity and biochar is well developed. It is relatively simple, cheap and can be scaled from a small village level unit (such as might serve the needs of a small hospital) up to very large automated systems. The main governing factor is the size of the supply of feedstock, and the efficiency of the distribution of the biochar.

The commencement of a project would not be dependent on an investment in biochar technology. Multiple benefits will be realised just by planting trees – without a single leaf being converted to biochar. This allows for the economics of the proposal to become clear in a 'real-world' trial prior to any decision being made.

Carbon markets

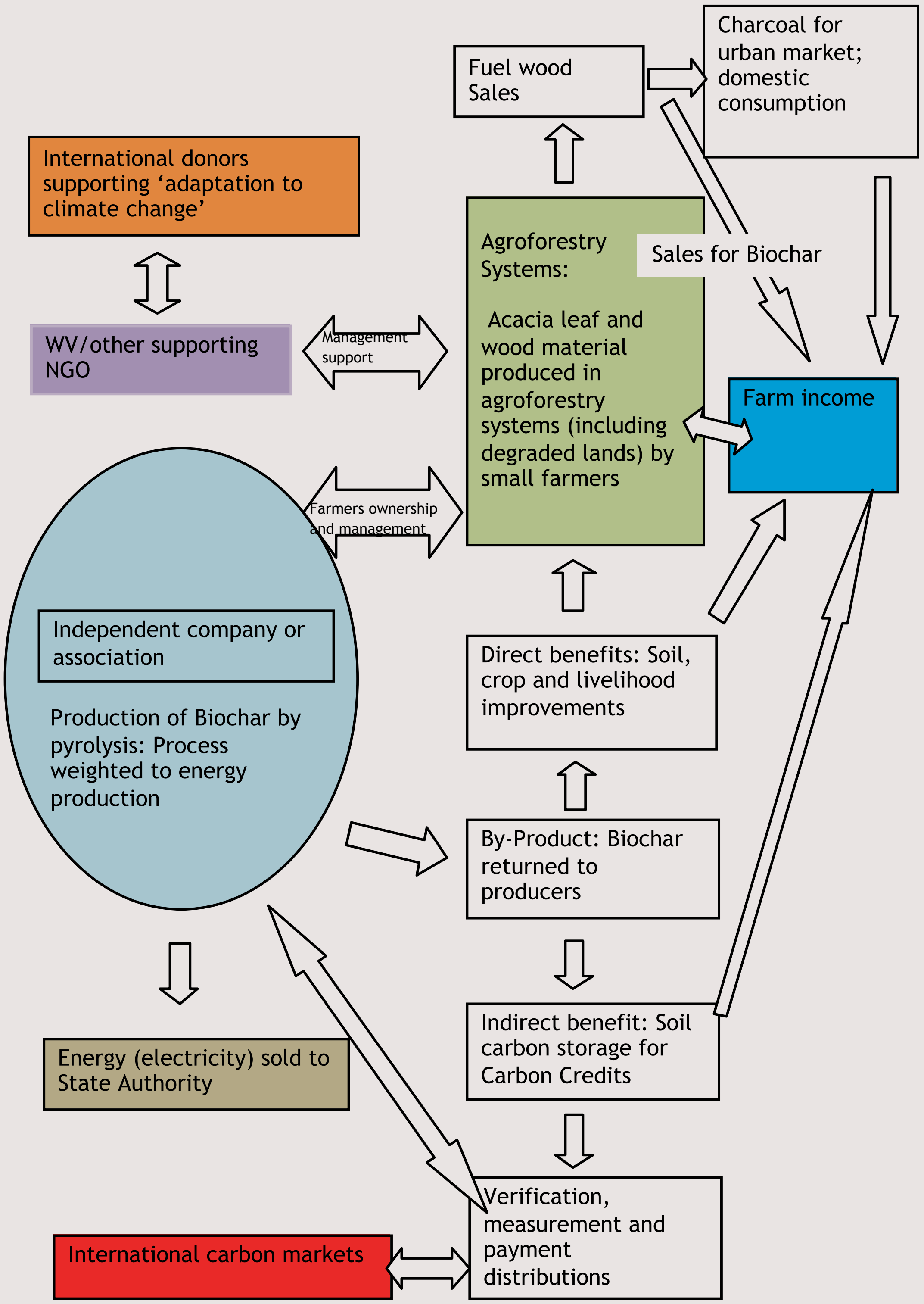
International carbon markets have been growing rapidly in recent years, a trend that can be expected to continue as emissions trading becomes established on a global basis. Prices have varied widely through time and across jurisdictions, indicating both the infancy of the market itself and its nature as an 'artificial' market that is strongly influenced by national legislative and regulatory frameworks.

The World Bank's Clean Development Mechanism (CDM) has taken a leading role in researching and verifying methodologies by which carbon capture can be measured under various conditions. The capture or preservation of carbon through forestry and land use change has been a major area of interest, however the lack of security inherent in carbon stored in trees and forests (especially in poor developing country environments) makes such investments risky, resulting in lower carbon prices and higher verification costs, factors that impact on the viability of projects on the ground. Biochar, on the other hand, offers a much more secure and (theoretically) easily measurable store of carbon in the soil.

In order to link small farmers in the Sahel with International carbon markets, the following would be required:

1. An efficient and approved protocol for the measurement of changes in soil carbon content.
2. A carbon broker. This could be the World Bank CDM or a commercial trading entity (probably in Europe).
3. An organisation capable of monitoring changes in soil carbon content on individual farms to the satisfaction of verification authorities and market actors.
4. A means by which carbon funds can be reliably and efficiently dispersed to participating farmers.

Figure 4: A possible biochar system for the Sahel.



Further research opportunities

- Identification and trialling of seed producing acacia species suited to <250mm/annum rainfall. A number of alternate species of Australian acacias have been observed to set seed in low rainfall years in Central Australia. Collections should be made and provenance and performance trials conducted in Niger.
- Trials to compare the cost effectiveness of banquettes and demi-lunes for the production of Australian acacias.
- Economic investigation and trialling of multi-product systems based around Australian acacias that can yield income streams from seed, wood, energy and carbon capture.
- Investigation and demonstration of the effects of biochar on Nigerien soils, its soil residence times in that environment and effective means by which soil carbon can be measured in the Sahelian environment.

Roadmaps for implementation

In this report I have discussed two regions where there is real potential for acacias to contribute powerfully to both agricultural resilience and the nutritional status of the population. In both cases, the next steps of implementation are relatively cheap, simple and can be implemented in a step-wise manner, with each step justifiable on its own terms, and building on previous advances. In practice, it may be difficult for World Vision Australia to implement the type of activities I have discussed concurrently in both regions, and so a choice may need to be made as to where a pilot would be most likely to succeed.

By ‘implementation’ in this context I mean a comprehensive program that encourages the growing of cacia trees on farms and degraded lands (or steep mountain slopes in the case of Tigrai), and use of acacia seed for improved nutrition in households; possible support to micro-enterprise activities aimed at creating a market for acacia seed and acacia seed products; and the development of a high quality, nutritionally balanced acacia-based complementary food for young children.

Niger

In the case of Niger, the many years of species and provenance trials offer a great head start, albeit that these trials have pointed to the need to identify more drought adapted species. Niger is also well ahead in terms of the use of Australian acacias as a multipurpose component in agricultural systems. The acceptance of acacia seed as a food is perhaps less certain, with knowledge of the seed largely restricted to the villages where SIM has focussed its work, though the emergence of small scale local processing points to the possibility that the acceptance of the Australian acacias is reaching a critical mass, at least in the Maradi region.

The main obstacle to implementation in Niger is a shortage of seed that will take at least two years to overcome. There are simply not enough trees planted to generate the volumes of seed required. The existence of a significant seed stockpile at Danja, near Maradi, does offer a way forward in the short term, so that product development and trialling can be undertaken, but the future of the project in Niger demands as a minimum that 20,000 trees be planted during the 2010-2011 rainy seasons. In fact this would require only 200 hectares of land, and given the will, is entirely achievable.

Another obstacle to successful implementation in Niger is organisational. The main SIM project officer who has been engaged in provenance selections and trials, and acacia promotions for the past ten years, is departing in late 2010, with no apparent successor to carry forward the task. As to the role of WV Niger: While there are a number of WV Niger field staff doing commendable work, faster progress could be made with the full commitment and follow up action by the National Office.

"The acceptance of acacia seed as a food is perhaps less certain, with knowledge of the seed largely restricted to the villages where SIM has focussed its work, though the emergence of small scale local processing points to the possibility that the acceptance of the Australian acacias is reaching a critical mass, at least in the Maradi region."

Table 8: Steps to implementation in Niger.

Timeline	Niger NGOs (esp. WVN, SIM, INRAN)	Trading organisation(s) (To be established)	World Vision Australia
Urgent	Continue to promote Acacias on farms and in agroforestry systems.		Quantify and identify funding for implementation. Time is of the essence!
			Identify main capital constraints to micro-enterprise success and devise a strategy for providing support.
Completed by November 2010	Identify potential areas of degraded land suited to acacia production. Begin a process of negotiation to secure at least 200ha. (see page 72).	(micro-enterprise). Develop Garin Dan Tahoua (acacia flour) product and define sales channels. Further develop Acacia kunu product and markets.	Approach WVN seeking commitment to implement the acacia project.
	Obtain permissions from the Niger Government.		Engage a suitable organisation (such as Valid International) to further develop and test the concept of an acacia kunu. Timetable trials for first half of 2011.
	Establish clear tenure, ownership and management agreements with degraded land project participants.		Employ a project officer specifically to promote acacia work in both Niger and Tigrai.
Completed by June 2011	Establish a semi-independent not-for-profit trading entity capable of operating legally in Niger.	Retain links to organisations such as WVE, WVA and TARI through directors.	The WVA Project Officer should be a Director.
			Convene a conference to mark the 20th anniversary of the Glen Helen event that kicked off acacia work. Ensure donors are invited.
	Participate in trials.	Prepare sufficient kunu product to support trials.	Participate in trials.
	Prepare seedlings for 2011 rainy season planting. Seedlings must be planted by March at the latest. Prepare demi-lunes on degraded lands using Cash-for-Work or Food-for-Work.	Develop relationship with a food company capable of producing quantity >100mt/annum, to required Codex Alimentarius standards.	Undertake collections of arid adapted Acacia species in Central Australia.
			Publish trial results in a peer-reviewed journal.
Longer term future	Continue to promote acacia systems and foods to new regions.	Produce acacia-based food for distribution by humanitarian agencies.	Promote acacia food to all relevant humanitarian agencies.
	Undertake trials and provenance selections of arid adapted species collected in Australia.		

Tigrai, Ethiopia

The situation in Tigrai, Ethiopia is very different to that in Niger. Whereas in Niger, much work has been completed on species and provenances, and on introducing acacia foods to the community, in Tigrai relatively little is known about the productive potential of A. saligna and the variations between provenances, and there is absolutely no knowledge in the community as to the food value of the seed. The major advantage to implementing the project in Tigrai is the millions of acacia trees that are already growing throughout the region. Thus the time-consuming task of scaling-up acacia seed production is removed, and the focus can be brought immediately to education. A further factor giving great promise in Tigrai is the dynamic engagement of World Vision Ethiopia (WVE) and the Tigrai Agricultural Research Institute (TARI) in exploring the potential of Australian acacias.

> “The major advantage to implementing the project in Tigrai is the millions of acacia trees that are already growing throughout the region.”

A comprehensive project is already being jointly undertaken by WVE and TARI, from 2009-2012, evaluating the viability of Acacia saligna as a component in agroforestry systems and as human food. The project will consider the physical forms of A. saligna that are extant in Tigrai, the productivity of various provenances, the nutritional value of the seed, the livestock feed value of the foliage and issues in promoting the seed to farmers as a potential staple food. Without wanting to pre-empt the findings of this set of studies, my experiences in Niger and Australia give me great confidence that A. saligna has enormous potential to provide food to an undernourished population in Tigrai. Whilst all steps toward implementation of a project could be delayed until all studies are completed, this imposes lengthy delays that will be felt as real, continued hunger and malnutrition by real people. Thus, I argue that once basic toxicology and nutritional testing is complete, that efforts to promote acacia seed as a human food should begin in earnest. In line with what I have argued elsewhere in this report, the approach should take in local and household consumption, as well as a longer term plan to include the acacia seed in a nutritional supplement designed for young children. The required steps would be as follows:

Table 9: Steps to implementation in Tigrai

Timeline	Tigrai NGOs (esp. WVE and TARI)	Trading organisation (To be established)	World Vision Australia
Urgent	Establish a semi-independent not-for-profit trading entity capable of operating legally in Tigrai.	Retain links to organisations such as WVE, WVA and TARI through directors.	Quantify and identify funding for implementation. Time is of the essence!
In place by November 2010	Educate a cadre of people able to move through the villages and run training sessions. Initially, training would need to cover harvest and preparation methods for the seed, with later sessions covering cultivation practices such as propagation and pruning.	Plan to encourage A. saligna seed harvest in November/ December 2010.This will require a concerted effort both prior to, and during the period of seed ripening.	
	Media promotion. Utilise all available media, especially radio, to teach how to harvest and prepare acacia seed.	Establish a basic infrastructure to purchase and store acacia seed. An initial target of 15-25 metric tonnes should be set for the first season. Price should be set at a similar level to other legumes such as lentils.	
November 2010 - June 2011	Maintain training focus to encourage household use of acacia seed, esp. for young children.		Engage a suitable organisation (such as Valid International) to further develop and test the concept of an acacia sebqo. Timetable trials for first half of 2011.
	Obtain permissions from Ethiopian Government.	Develop relationship with a food company capable of producing quantity >100mt/ annum, to required Codex Alimentarius standards.	Publish trial results in a peer reviewed journal. Promote results (assuming positive), to Humanitarian agencies active in Tigrai and across the region.

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