Towards Sustainable Nutrition Improvement in Rural Mozambique: Addressing Macro- and Micro-nutrient Malnutrition Through New Cultivars and New Behaviors

Proposal Submitted by the Nutrition Division of the Ministry of Health in Collaboration with Michigan State University, World Vision International, Helen Keller International, the National Institute for Agronomic Research, and the Southern African Root Crops Research Network

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Project Overview

The goal of this proposed project is to improve dietary quality through the promotion of diet diversification and modified food habits, particularly young child feeding practices, in rural Mozambique. Emphasis will be placed on addressing two major nutritional problems: vitamin A deficiency and inadequate caloric intake. To achieve this, the project will introduce and evaluate pro-vitamin A (beta-carotene) rich varieties of sweet potato (identified by their orange-flesh), utilizing these new cultivars as a low-cost, effective entry point for improving the kinds of weaning foods given to young children and increasing the frequency of intake of essential micro-nutrients and calories.

Orange-fleshed sweet potatoes have been selected as the key intervention component as they are an excellent source of pro-vitamin A and calories, easy to cultivate, vegetatively propagated, fairly drought resistant, typically considered a woman's crop, and serve as an excellent food security crop. Sweet potato is less labor intensive than most other staple crops and can be planted over a considerable range of time without considerable yield loss. With adult labor availability highly likely to diminish as the AIDS epidemic continues its spread, sweet potato and cassava cultivation are important AIDS mitigation strategies for assuring adequate caloric availability at the household level[1]. Moreover, as white-fleshed sweet potatoes are

[1] The World Bank reports a single adult death depresses per capita food consumption in the poorest households by 15%, implying that AIDS deaths occurring in poor households exacerbate poverty and food insecurity (The World Bank 1997). "The critical link between food insecurity, gender and HIV, though scarcely documented is important. FAO research in Uganda and in West Africa shows that the most immediate problem for many AIDS-affected female-headed households is not medical treatment and drugs but food and malnutrition. It appears that when a household has been affected by male adult mortality, surviving widows and their families often have few, if any, assets to dispose of in their time of need. Thus, food security coping strategies may disintegrate quite soon after male adult death and food consumption may decline sharply. For this reason, food security and nutrition should be key elements in the response to HIV"(Topouzis 1998, p. 19).

already grown in a large portion of Mozambique, families would only be making a *marginal* change in their dietary habits. The key hypotheses are that adequate consumption of sweet potato-based weaning foods by young children and sweet potato roots and leaves by adults will lead to a significant improvement in the diversification of both young child and adult diets and that the cultivation and appropriate uses of this important pro-vitamin A rich food can become permanent and sustainable practices in rural Mozambican households.

The impetus for this research-intervention project arises from a pilot project which introduced orange-fleshed sweet potatoes among 20 women's groups in Western Kenya (Hagenimana et al. 1999b; Low et al. 1995). Results showed that selected varieties were acceptable to consumers and incorporated into their farming system and certain groups successfully developed and marketed sweet potato-based processed products. The most important finding, however, was that increased frequency of consumption of vitamin A-rich foods by young children was higher in the intervention groups receiving extensive nutrition education in addition to the new varieties, as opposed to the children of women in control groups, where only the agricultural component was introduced. This finding is consistent with evaluations of other attempts to improve household food security, which have found that increases in the availability of certain foods typically do not result in improved child nutritional status when no additional effort has been made to specifically improve nutritional practices (Dickin et al. 1997).

The nutrition intervention in the Kenya project was based on extension personnel holding demonstration and discussion sessions with women in groups, followed by monthly or bi-monthly visits to individual women in their home. While such a strategy worked, the process was not documented in detail, nor can one establish what are the minimum number home visits essential for assuring sustained adoption of the new food habits. Dietary interventions for improving vitamin A are often criticized for being too costly, particularly when compared to supplementation programs based on the semi-annual distribution of high-dosage capsules which only require caregivers to passively accept that their child receive the capsule, whether or not they understand why the capsule is being distributed.

Advocates of dietary interventions point to several benefits, however, of pursuing this approach as part of an integrated strategy to tackle chronic malnutrition. Some major advantages are:

- Dietary interventions address the underlying causes of malnutrition and poverty, empowering women through providing them with greater access to improved technologies and existing knowledge.
- If the new dietary habits and agricultural practices are adopted, the benefits for vitamin A status are likely to be sustained over time, eventually reducing the need for prophylactic capsule distribution to the entire under-five population
- Unlike like high-dosage supplements, dietary interventions enhance the intake of number of other important micro- and macro-nutrients, thereby enhancing the overall quality of the diet. In the case of sweet potato, for instance, caregivers can produce sufficient calories more efficiently and sweet potato leaves also supply a number of micro-nutrients in addition to beta-carotene.

Thus, **a critical component of this project is to determine what is the most cost-effective strategy for implementing a intervention focused on improving dietary quality through dietary diversification and improved feeding practices.** Particular attention in this proposed effort will be paid to:

- ♦ understanding of the impediments women face in changing their child feeding practices and how extension personnel can assist women in overcoming those impediments in the most cost-effective manner possible
- ♦ design interventions with components that will enhance the sustainability of the adoption, such as activities which generate income using the new varieties and permanent incorporation into on-going extension and formal education training programs
- ♦ developing realistic methodologies to capture the diverse nature of benefits accruing from such interventions.

This proposal will describe in detail a two and a half year intervention-research-capacity strengthening project. To succeed in obtaining the objectives of this proposal at reduced cost, the project will be attached to a larger 5-year integrated agriculture-nutrition initiative to be initiated by World Vision International in 10 districts in Zambézia Province beginning in October 2001. **The ultimate objective is to have a tested methodology in two districts that by the end of the proposed project period (2.5 years) can be effectively scaled up to within 8 districts of Zambézia within World Vision´s project mandate and other parts of Mozambique.**

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Problem and Justification

A. Micronutrient Malnutrition

During the past 15 years, there has been increasing interest worldwide in identifying and treating micronutrient deficiencies. Nutritionists in many developing countries have assembled compelling evidence that many children, especially young children, and adults are affected by a lack of essential vitamins and minerals in their diets (United Nations 1997). Such deficiencies can lead to decreased work performance, impaired cognitive development and physical growth, more severe bouts of illness, poor eyesight, and increased maternal and infant and child mortality. While people are generally quite aware when their calorie consumption is inadequate, the opposite is true for diets deficient in trace nutrients. Hence, the problem of poor diet quality is often referred to as *hidden hunger*.

Three micronutrient deficiencies-- iron, vitamin A, and iodine are most often targeted for intervention because of the enormous magnitude of these problems. Globally, approximately 2.1 billion people are iron-deficient, resulting in anemia among an estimated 1.2 billion people (United Nations 1997). In adults, iron deficiency reduces the capacity for physical labor and increases the risk of maternal mortality, while deficiencies in childhood can impair physical growth and mental development. Iodine deficiency is the most prevalent cause of preventable mental retardation in the world (Delange 1994). The extent of goitre, the most visible result of iodine deficiency, has been estimated in 1990 by the World Health Organization (WHO) and International Council for Control of Iodine Deficiency Disorders (ICCIDD) as affecting more than 200 million people, with an addition 5.7 million suffering from overt cretinism (Nations 1992). Improving vitamin A status of deficient children would not only save a half a million children from going blind each year, but would also lead to a marked reduction in childhood mortality ---annually saving a million or more lives (Sommer and West 1996).[2]

Greater awareness of the *hidden hunger* problem has led to a massive commitment on the part of over 120 countries, including Mozambique, to try to eliminate iodine and vitamin A deficiency and significantly reduce iron deficiency in developing countries by the year 2000. Emphasis in many countries was initially placed on supplementation programs, in the belief that capsule/supplement distribution could solve the micronutrient problem quickly. However, while experience has shown that universal supplementation can be cost-effective, it must be repeated every six months. Thus, in many countries with poorly developed health and road infrastructure, supplementation can be logistically difficult to implement, and can only be sustained with continued massive financial support of outside donors. If supplements are targeted, there are additional costs associated with identifying those in need. A second approach, that of fortifying common foods with a micronutrient, has been used successfully in some instances. Salt fortification with iodine has been the one of the most successful efforts in this regard. However, in countries where markets for foods are not well-developed, it has been difficult to identify

[2] "Severe vitamin A deficiency has very high fatality rates (60%) but even subclinical deficiency is associated with a 23% increase in preschooler mortality in areas with endemic vitamin A deficiency" (McGuire, 1993).

appropriate foods to fortify. Moreover, legal infra-structure has to be sufficiently strong to ensure that manufacturers comply with fortification laws. The third approach is to improve dietary quality and quantity through dietary diversification. The goal is to achieve and maintain an adequate intake of micronutrient-rich foods in the context of an adequate total diet (World Health Organization 1996). In countries where market systems are not well-developed and the capacity for legal enforcement is limited, such food-based approaches are probably the most sustainable of the various interventions. Such an strategy requires an inter-sectoral perspective, which means providing agricultural and educational inputs, with an awareness of cultural, socio-economic, and market conditions. Given the synergistic relationship between some deficiencies and infectious and parasitic diseases, it is also advisable to address simultaneously helminthic infections, diarrhoeal disease problems, measles, and protein-energy malnutrition (World Health Organization 1996). Experience to date has shown that a mix of approaches is most desirable (United Nations 1997), with the most appropriate combination being determined by the administrative and financial capacity within each country.

In general, vitamin A intake is often inadequate because of the seasonality of food sources, early cessation of breastfeeding, high morbidity levels and the practice of not giving vitamin A-rich foods to young children (McGuire 1993). Among the major micronutrient deficiencies, vitamin A deficiency is most amenable to agriculturally-based interventions (Food and Agriculture Organization and the World Health Organization 1992). For this reason, vitamin A is the micronutrient selected for the focus of this intervention/research project and the remainder of this section will summarize relevant facts concerning vitamin A.

Vitamin A is found, in large amounts, in a relatively small number of foods. Vitamin A in animal foods is mainly in the form of retinol, and in plants is mainly in the form of beta-carotene and other carotenoids. Vitamin A from animal sources is most easily used by the body, but there are few good sources---liver, milk, eggs, and butter. Among the plant sources, vitamin A from dark orange fleshy fruits and vegetables (such as ripe mango, papaya, or sweet potato, but not oranges), appears to be more bio-available (absorbed and utilized) than the vitamin A from dark leafy greens (Khan et al. 1997); (de Pee et al. 1995); (Jalal et al. 1998).[3]

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[3] The commonly used conversion factors for estimating vitamin A intake are based on two studies conducted in the 1940s and reflect the higher bio-available of animal sources of vitamin A over plant sources:

1 µg retinol = 1 Retinol Equivalent (RE), from animal sources

6 µg all-trans beta-carotene = 1 RE

Recent work among school children in Indonesia and breastfeeding women in Vietnam which compared the increase of serum retinol from feeding different types of foods calculated the following apparent conversion factors:

Retinol-rich foods (animal sources): 1 µg retinol = 1 RE

Fruits, pumpkin, orange-fleshed sweet potatoes: 12 µg beta-carotene = 1 RE

Dark green leafy vegetables or carrots: 26 µg beta-carotene = 1 RE

Absorption varies considerably depending on the initial health status of the individual. For example, persons with very low serum retinol status initially absorb more than those with better status. The presence of inhibitors, such as fiber, and enhancers, such as fat, are also major

Since the early 1990s, the main strategy for combating vitamin A deficiency has been to distribute massive dose capsules to children identified as being deficient during clinic examinations or as part of national vaccination campaigns. While the benefit to cost ratios for such supplementation exercises can be significantly high, there are major *recurrent costs* involved as the exercise must be repeated at regular intervals for the indefinite future. To date, the most cost-effective strategy for distributing vitamin A capsules has been to link it to the polio eradication campaign. Since that campaign will end by 2001, other effective means of increasing vitamin A intake will need to be sought. Since vitamin A deficiency peaks in children 2 to 3 years of age (Levin et al. 1991), and mothers tend to stop bringing children to monthly clinics after completing infant immunizations at 9 months of age or even sooner, linking capsule distribution to current immunization programs will not be sufficient. Thus, alternative approaches not based on vitamin A capsule distribution should be examined for cost-effectiveness and long-term sustainability.

B. Policies Regarding Macro- and Micronutrient Malnutrition in Mozambique

Mozambique has recently emerged from a 17 year long civil conflict with the signing of the peace accord in 1992. Resettlement of internal and external refugees plus floods and droughts resulted in heavy dependency on food aid imports to assure sufficient staple food supplies at the national level. Since 1994, remarkable progress has been made in lowering dependency on imported staples, as agricultural production has increased and macro-economic conditions have greatly improved. However, the colonial legacy of concentration on large-scale agricultural development at the expense of the smallholder sector, coupled with the devastating losses of livestock and agricultural capital during the war, has left the vast proportion of the rural Mozambican population poor and largely dependent on semi-subsistence agriculture for survival. A 1996/97 nationally representative survey found 71% of the rural Mozambican population falling below the poverty line (Ministério do Plano e Finanças et al., 1998). Educational levels of the population are low, particularly for adult rural women. While access to land is relatively good, there is little use of improved cultivars, fertilizers, and labor-saving devices to increase agricultural output. While considerable improvement has been made in rural infra-structure since 1992, parts of Mozambique are subject to periodic flooding which has hampered progress. Hence, the majority of the rural population lack sufficient access to most services. Widespread poverty and inadequate health care are the key underlying factors explaining the high levels of stunting found among children under five years of age in rural Mozambique (44% falling below -2 Z-score for height-for-age (Ministério do Plano e Finanças, et al., 1998).

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factors determining differences seen in bioavailability among plant sources (de Pee 1999). These results need to be confirmed. However, given the very high level of beta-carotene present in orange-fleshed varieties of sweet potatoes, it still remains an excellent source of vitamin A (greater than 100 Retinol Equivalents/100 grams), even at half of the commonly used conversion rate and taking losses due to preparation into account. These results do, however, indicate that emphasis should be placed on promoting sweet potato roots over sweet potato leaves.

In response, the government has committed itself to a strategy to tackle poverty and assure adequate food security and the nutritional well-being of its population. In 1998, the government adopted a new government determined framework for doing agricultural development, PROAGRI, which has as its principal goal the development of agricultural activities in the family sector, based on policies and programs to diversify and expand smallholder agriculture, encouraging commercialization of crop production as well as increased production for home consumption. In planning exercises to date, PROAGRI has focused on strategies for improving *availability* and *access* to food, through improvement of market infra-structure and liberal marketing policies, as well as intensification and increased commercialization of agricultural production. *Availability* and *access* are two of the pillars of the National Food Security Strategy. The third pillar is *utilization. Utilization* deals more with the issue of diet *quality* than quantity, recognizing that to be healthy, a person can not thrive on maize alone. Moreover, *utilization* of absorbed nutrients depends on health status as illness can seriously interfere with adequate nutrient absorption. To achieve the major food security objective of PROAGRI, extension personnel will need to promote interventions that will address all three aspects-- *availability, access,* and *utilization* among the 3 million smallholder households targeted under this scheme.

The Nutrition Division of the Ministry of Health has played an integral role in putting food security issues on the national agenda, particularly in regards to recognizing the critical linkages between the agriculture, nutrition, and heath sectors. Results from District-Level Food Security Profiles done in 1996-98 indicate that food insecurity is a serious problem. In certain drought-prone parts of the country, food insecurity is a year-round problem among very poor households. In others where a significant proportion of the population depends on rainfed agriculture, the food insecurity problem is seasonal in nature. There is a high dependence on a few staple foods (cereals and manioc) for the majority of caloric needs with lack of diet diversity being a major problem. Access to animal products is extremely limited at the household level due to high cost and often limited availability in rural areas. The tsetse fly limits livestock rearing in many central and northern parts of the country, and where livestock rearing flourished, mostly in Southern Mozambique, herds were often decimated during the war and rebuilt herds were diminished by massive floods in February-March 2000. Newcastle's disease is a major constraint to sustained chicken rearing.

Limited data exist on the extent of micronutrient malnutrition in the country. However, there is growing awareness of the importance of the problem as reflected in the strategic plan presented in the 1999 Micronutrient Malnutrition Strategy of the Nutrition Division. Considerable strides have already been made in tackling iodine deficiency, with iodinization of salt becoming a reality in 1996 (although maintain iodinazation programs has proved problematic). Short and long-term strategies are now being developed to deal with vitamin A and iron deficiency. Again, as this project will focus on vitamin A, the remainder of this section summarizes the current state of knowledge regarding the extent of vitamin A deficiency in Mozambique and policies regarding vitamin A.

In 1998, the Nutrition Division, in collaboration with Helen Keller International, conducted an assessment of community-level risk of Vitamin A deficiency in four provinces: Maputo, Gaza Provinces, Manica, and Cabo Delgado. Results representative at the provincial level were obtained from 3399 households using the HKI food frequency method which focuses

on young children's intake of vitamin-A rich foods (Ministry of Health 1998). The food frequency method provides two criteria for assessment: a total vitamin A score with values *less* than 6.0 or a total score from animal sources of vitamin A with values less than 4.0 indicating the population is at risk of a vitamin A deficiency problem of public health significance. None of the provinces exceeded the cut-off points using either criteria. Total vitamin A scores ranged from a low of 1.75 in Gaza to a high of 3.74 in Manica Province, indicating a high probability of vitamin A deficiency in these areas.

The same food frequency methodology was applied to 3 districts in Nampula (the most populous province in Northern Mozambique) and 3 districts in Zambézia (the most populous district in Central Mozambique) by World Vision Mozambique with support from Helen Keller International and USAID. Similar results were found, with all surveyed districts clearly demonstrating risk of a vitamin A deficiency problem of public health significance (Arimond 1998).

The food frequency assessment is an indirect indicator, but given Mozambique's high infant mortality rate (200 per 1000 children) it is widely accepted that a significant sub-clinical vitamin A deficiency problem exists (UNICEF 1990)[4]. Moreover, results from national and sub-national surveys among 15 Sub-Saharan African countries of sub-clinical vitamin A deficiency assessed biochemically on the basis of low serum retinol in children under five years old clearly demonstrated that all countries surveyed had a vitamin A deficiency problem of public health importance (United Nations 1997)[5]. It would be highly unlikely that Mozambique would be better off than its neighbors in this regard.

Recognizing the severity of the problem, the Ministry of Health, with support from UNICEF, undertook the first distribution of vitamin-A rich capsules to children at risk of

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[4] Since many countries do not have up-to-date national-level assessments of the prevalence of vitamin A deficience, WHO developed a number of indirect indicators (World Health Organization 1996), including information on protein-energy malnutrition, food consumption, morbidity, low birth-weight, immunization coverage, access to health services, and socio-economic indicators. The technical consultation convened in 1998 concerning combating vitamin A deficiency recommends that a high child under five mortality rate (defined as >70 deaths per 1000) should be taken as an indicator of a likely vitamin A deficiency problem of public health importance. High mortality, preferably taken in conjunction with another indirect indicator of vitamin A deficiency (e.g. poor immunization coverage, the food frequency consumption indicator, or high levels of chronic malnutrition) is sufficient evidence to trigger governments to launch programs to combat vitamin A deficiency (UNICEF 1998).

[5] Results indicating vitamin A deficiency of public health importance are based on a cut-off of prevalence of low serum retinol >10%. The prevalence found in 15 African countries in which nationally or sub-nationally representative surveys have been undertaken since 1982 are as follows: Botswana (32.5%); Burkina Faso (70.5%); Cameroon (19.7%); Congo (26.0%); Côte d'Ivoire (46.6%); Ethiopia (38.9%); Ghana (54.9%); Kenya (33.0%); Lesotho (77.0%); Mali (73.0%); Mauritania (41.6%); Namibia (20.4%); South Africa (30.0%); Tanzania (45.3%); Zambia (16.5%) (United Nations 1997).

deficiency in July 1999. This first campaign was linked to the country-wide polio vaccination campaign. The second campaign, scheduled approximately six month after the first, was postponed until mid-June 2000 due to massive flooding occurring in Southern and Central Mozambique in February and March 2000. The Ministry of Health views capsule distribution as a short-term solution to the vitamin A deficiency problem which is unlikely to be sustainable without continued massive donor support. Therefore, the National Micronutrient Strategy strongly advocates the development of alternative approaches to dealing with vitamin A deficiency, preferably those that would eliminate the need for capsule distribution for the vast majority of the population at risk. Concentration on dietary-based approaches that simultaneously address the need for greater caloric consumption as well as improved diet quality are most appropriate for conditions faced by rural Mozambicans and are in accordance with the stated goals of the nation's food security strategy.

C. Rationale Underlying the Dietary Intervention Strategy

According to Sommer and West (1996), until recently it was "generally accepted that gardening and better food preservation and processing methods, integrated with educational efforts to change feeding practices, will prove effective in improving the vitamin A status of a population." However, attempts to prove this have yielded mixed results and created active debate among nutritionists about what kinds of food-based interventions will result in improved vitamin A nutriture.

Reviews of successful nutrition education programs in developing countries have emphasized some common themes. Integration of interpersonal and media channels (including traditional or "folk" media) is a common characteristic of many successful programs. Different channels influence different stages of the behavior change process. (Cerqueira and Olson 1995); (Zeitlin and Formacion 1981). In addition, development and testing of messages that respond to the needs of program participants ("receiver-oriented" messages) is another key feature of successful programs (Cerqueira and Olson 1995), (Favin and Griffiths 1999). Trials of improved practices (TIPs) are one method to achieve this (Dickin et al. 1997). TIPs constitute the core method in a consultative research approach which offers the potential to gain in-depth understanding of feeding practices, motivations and constraints to behavior change[6]. This process identifies effective and practical behavior changes which are acceptable and feasible for families.

Regardless of the methods and media used to promote and support behavior change, it is a challenging task. Therefore, in this food-based approach to nutrition improvement, the choice of crops is key. Any introduced varieties must be agronomically viable, culturally acceptable, palatable to local tastes, and not too onerous to prepare. Sweet potato is a logical choice for such an intervention as white-fleshed varieties (lacking beta-carotene) are already widely cultivated in

[6] Typically, several visits are made in to caregivers in carefully selected households. Current nutritional practices are analyzed in the initial visits. During follow-up visits, the researcher negotiates some specific changes in feeding practices that the caregiver follows for a set period of time. Researchers subsequently learn from mothers which practices work.

Mozambique, and therefore the promotion of beta-carotene-rich varieties (orange and some yellow-fleshed varieties) is facilitated by only requiring a *marginal* change in dietary habits, a much easier task than, for instance, asking rural Mozambican households to consume carrots. An intervention/research project in Western Kenya found widespread acceptance of orange-fleshed sweet potatoes, with education concerning the nutritional quality of the new varieties being key to women regularly incorporating sweet potatoes into weaning foods of their children (Low et al. 1995). At the end of the two year project, the introduced varieties were still being grown, and an active market for selling vines to others emerged to due demand from other farmers. However, it is critical to pay attention to differences in taste preferences between adults and young children when selecting varieties to introduce. Like most adults in Sub-Saharan Africa, Kenyan women were found to prefer "mealy" sweet potato varieties high in dry matter content regardless of pulp color, whereas the young children preferred the mushier, low dry content varieties (Low et al. 1995).

There are many other important reasons why the introduction and promotion of introduced orange-fleshed sweet potato varieties will be the key intervention component in this project:

- Regular intakes (100 grams per day or half-cup) of yellow or orange-fleshed sweet potato roots having moderate β-carotene concentrations (e.g. 3 mg/100 grams on a fresh weight basis) provide the recommended daily amount of vitamin A for children under five years of age (Tsou and Hong 1992). Moreover, results from a clinical trial in Indonesia (Jalal et al. 1998) showed that the incorporation of beta-carotene sources (mainly in the form of orange-fleshed sweet potatoes) into the meal given to 3-6 year olds significantly increased serum retinol concentrations (i.e. improved vitamin A status)
- Sweet potatoes are an excellent source of calories as well as beta-carotene. Compared to other major developing country staple foods, sweet potatoes dominate in terms of quantity of energy per hectare per day which they can produce (Table 1);
- Sweet potato leaves are good sources of several vitamins: beta-carotene, thiamin (B_1), riboflavin (B_2), folic acid, and ascorbic acid (C) (Woolfe 1992). Unlike in most of Eastern Africa, sweet potato leaves are widely consumed in Mozambique. Leaves can also be used for animal feed, particularly for dairy cattle and goats, and sweet potato roots are an excellent pig feed;
- Improved cultivars typically have higher yields and shorter maturity periods (4-5 months) than varieties currently grown in much of Sub-Saharan Africa (7-10 months). Having 2 harvests per year is feasible in many areas of Mozambique, particularly in the central and northern provinces, which will vastly enhance calorie availability;
- Sweet potato can grow on soils of limited fertility, is relatively drought tolerant, provides good ground cover, and is usually cultivated without fertilizer or pesticide (Ewell 1990);
- Sweet potato is a classic food security crop. Once mature, sweet potato is often harvested "piecemeal" over a period of several months. Therefore, it is ideal for filling gaps in food availability from other sources;
- In most parts of Africa, sweet potato is generally considered to be a "woman's crop." Time-constrained women in Mozambique could rely on low-labor input crops such as sweet potato to feed themselves and their families particularly when other major sources of carbohydrate are unavailable;

- Sweet potato is vegetatively propagated; that is, segments of sweet potato vine are the principal planting material for farmers. Therefore, once established, farmers' have their own continuous supply of sweet potato "seed" and farmer-to-farmer varietal transmission is typically the predominant mechanism for varietal distribution within a community.

Table 1. Comparative Energy Yields of Sweet potato and Other Major Crops

Crop	Average Tropical Yield (Tons/ Hectare	Edible Energy Value (MJ/kg)	Proportion of Edible Energy (%)	Edible Energy per Hectare (10^3 MJ)	Average Crop Growth Period (Days)	Edible Energy (MJ/ha/day)
Roots/Tubers & Bananas						
Sweet potato	7	4,8	88	27,2	140	194
Cassava	9	6,3	83	45,6	330	138
Yam	7	4,4	85	26,2	280	94
Banana	13	5,4	59	41,4	365	113
Cereals[a]						
Rice[b]	2	14,8	70	20,8	140	149
Maize	1	15,2	100	18,8	130	145
Sorghum	<1	14,9	90	11,1	110	101
Millet	<1	15,0	100	8,2	100	82

Source: Woolfe (1992), p. 4 Notes: Based on de Vries et al., 1967.
[a] Cereals, air-dry; roots/tubers/bananas fresh.
[b] Paddy Rice.

The proposed intervention/research project utilizing orange-fleshed sweet potato varieties could not be more timely. Under the auspices of the Roots and Tubers Program of the National Institute of Agronomic Research (INIA), preliminary trials were conducted in 1997 and in 1998 on 38 orange-fleshed sweet potato varieties imported into the country with assistance from the Southern African Roots and Tubers Network (SARRNET) and the International Potato Center (CIP). Of these, 20 proved suitable to conditions in Southern Mozambique. Helen Keller International, through funds obtained from USAID Mozambique, supported

INIA/SARRNET to conduct 19 provincial level research trials during two growing seasons in eight provinces: Nampula, Zambézia, Manica, Sofala, Tete, Gaza, Inhambane, and Maputo. Results from the first round of trials indicate that 8 of the 20 varieties tested exhibit fairly broad adaptability across a wide range of agro-ecologies (Andrade and Ricardo 1999). Unfortunately, several of the second round trials were destroyed in the February-March 2000 floods and results from the second round will be reported once emergency work has ceased.

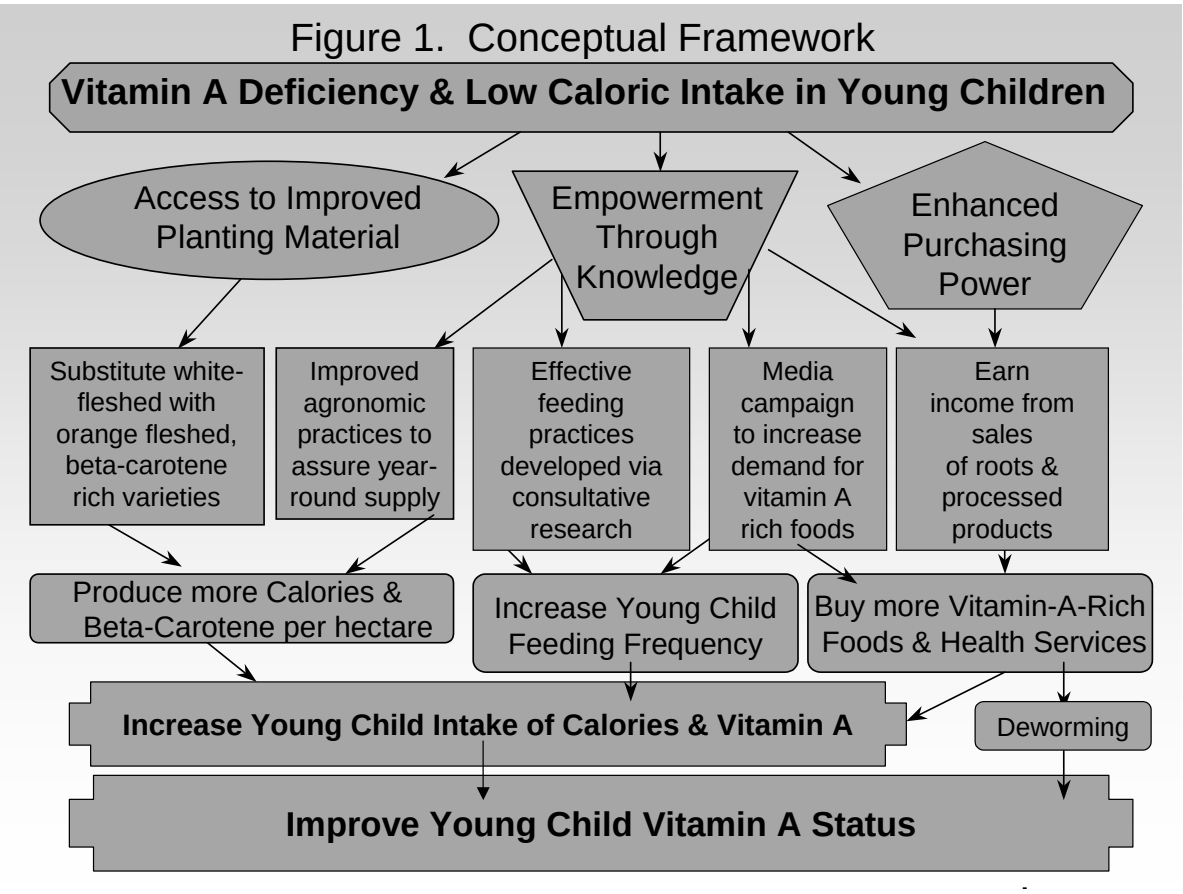
Increased fat consumption will also be a major focus of the dietary intervention. Like many other rural areas in Sub-Saharan Africa, the diet of the rural poor in Mozambique is characterized by low levels of fat consumption. Young children in particular need fat in their diets for a variety of reasons. Because young children can only eat a small amount at a time, it is important that they have energy/calorie-dense foods. Since fat provides more than twice as many calories, per gram, as carbohydrate or protein, addition of fat to food is the best way to increase caloric density. Fat also tends to make food more palatable to young children. Finally, fat is needed for optimal absorption of vitamin A. Young children need at least a little fat in their food each day. Ideally, any dietary improvement strategy aimed at young children, should raise fat consumption. Major fat sources to be promoted in the project will depend on local and seasonal availability of typical sources (for example, groundnuts, cashew nuts, sunflower, sesame and coconut oil).

One other major question is to what extent the absorption of ingested vitamin A is hindered by poor health status, and whether to be successful food-based strategies should include a health care component. The clinical trial in Indonesia (Jalal et al. 1998) utilizing sweet potato-based weaning foods demonstrated that the greatest rise in serum retinol occurred when meals contained added beta-carotene sources and added fat and the children were de-wormed. If a health care component is to be included in the intervention strategy, it must be relatively inexpensive to administer if it is to be sustainable. The feasibility of including a health care component will be assessed during the first stage of project implementation. However, if not feasible, Jalal's results clearly indicate that a substantial gain is obtainable just through the regular consumption of the sweetpotato based weaning food.

Conceptual Framework

As shown in Figure 1, there are three major pathways through which the project will achieve its goal of increased production and intake of vitamin A rich foods. These are through:

1) *Access to Improved Planting Material:* Women farmers will receive (principally through groups) planting material of high-yielding beta-carotene rich varieties (HBCR) and be directly involved in varietal evaluation. Rapid multiplication, staggered planting, improved agronomic practices and out-of-ground storage techniques will be introduced to ensure year-round availability of orange-fleshed sweet potato in both the adult and young child diet. Production of other locally available nutrient rich crops will be encouraged and facilitated over time as part of the larger project.



2) *Empowerment through Knowledge:* Levels of formal education achievement among adult rural women in Zambézia province are abysmally low (84% of women 20 years and above never attended school) (INE) 1999). Health and knowledge surveys in many other parts of Mozambique have noted several major areas where caregiver awareness of basic child feeding practices is severely lacking, including:

a. Duration of exclusive breastfeeding
b. Preparation of appropriate complementary foods and correct timing of introduction of different foods into the young child diet
c. Frequency of feeding of young children in different age groups

Key to the knowledge empowerment process is the interactive development between researchers, extension personnel and caregivers of weaning foods and child feeding practices that are cognizant of the daily constraints faced by the principal caregiver, including financial (lack of purchasing power), time (lack of time for complex food procurement and preparation), and cultural (beliefs, preferences, and pressure from influential relatives) constraints.

Most surveys only interview women about this type of knowledge, but it is highly likely that men are equally unaware of appropriate child feeding practices. Special attention will be given to assuring that men also have a thorough understanding of the most basic concepts so that they can actively support major behavioral changes occurring within the households. Promotional campaigns at the community, district, and provincial levels will facilitate widespread acceptance of improved child feeding practices and use of new cultivars by men as well as women.

3) *Enhanced Purchasing Power:* There are two principal mechanisms through which dietary diversification can be achieved at the household level. The first is the **direct production** of crops containing significant quantities of the desired nutrient. The second is through **market purchase**. Given the poor quality of the soil in the target districts, sweet potato is one of the few crops that can give acceptable yields without significant use of inorganic or organic fertilizers. Many of the other micronutrient rich foods will have to be purchased in the market. Enhancing the purchasing power of caregivers vastly improves their capacity to capitalize on whatever new knowledge they have obtained.

Given the poor market structure in the target area, the project will emphasize the development of sufficient market access as one of its key priorities. Since both cassava and sweet potato are women's crops, developing markets for dried, chipped cassava or sweet potato (which is later processed into flour) would provide much value-added income for women[7]. Moreover, in the case of sweet potato, orange-fleshed sweet potato flour can substitute up to 30% of wheat flour in many processed produced without affecting overall quality. This would vastly enhance vitamin A intake for urban and rural consumers not currently producing their own stock of orange-fleshed material.

In this framework, orange-fleshed sweet potatoes are the **entry point** for improving caloric and vitamin A intake among young children. However, it is expected that increases in other vitamin A rich foods will also increase significantly due to the impact of greater knowledge regarding which foods to produce and feed to young children combined with greater capacity to buy vitamin A rich foods through the sale of processed products.

Goals and Principal Outputs of the Proposed Project

[7] Low production levels reflect poor soils, the effects of droughts and cyclones, the lack of available agricultural inputs (particularly improved planting material and low skill development). To date, little attention has been paid to crops under the control of women, particularly roots and tubers. Roots and tubers are bulky to transport in their fresh form. Given the poor state of basic road infrastructure in these areas, the only economical way to transport cassava or sweet potato to major urban centers within Zambézia is as dried chips.

The overriding goal of this project is to **determine whether a food-based intervention strategy can lead to sustainable, year-round intake of vitamin-A rich foods, reduced fluctuations in seasonal calorie supply, and an overall improvement of diet diversity, nutritional status and diet quality in a cost-effective manner**. By the end of the project, sufficient detailed information will have been gathered to establish what is the most efficient way to effectively introduce new agricultural and processing technologies utilizing the improved sweet potato varieties and to modify behaviors regarding child feeding practices. This knowledge will serve as a basis for designing the next program phase which will focus on the process of scaling-up this pilot effort on a much larger scale.

The specific objectives and detailed outputs expected by the end of the project period are outlined below:

Objective 1. Adequate Supply of High-Yielding Beta-Carotene Rich (HBCR) Planting Material Assured

- Increased availability of vitamin A in the diet through the introduction and extensive dissemination of beta-carotene rich sweet potato varieties and through better use of locally available vitamin A sources;
- Increased farmer productivity through the provision of low input, high yielding beta-carotene rich sweet potato varieties which are in effect increasing household level incomes and calorie availability;

Objective 2. Reduction in Seasonal Fluctuation of Calorie Supply and Vitamin A Supply from Plant and Animal Sources

- Increased availability of vitamin A in the young child diet through the introduction and extensive dissemination of beta-carotene rich sweet potato varieties and through better use of locally available vitamin A sources;
- A demonstrated significant reduction in seasonality of sufficient caloric and vitamin A availability at the overall household level;
- Improved diet quality and caloric intake through increased availability and use of dietary fat in the young child diet;

Objective 3. Modified Food Habits, Improved Child Feeding Practices and Improved Serum Retinol Levels (Vitamin A Status) Achieved

- Increase knowledge of communities regarding the role of sweet potato and other vitamin-A rich foods in the diets of both children and adults through working directly with womens' and farmers' groups, mobilizing public health workers, and utilizing mass media;
- A clear set of simple practices using sweet potato based weaning foods developed through extensive consultative research with parents to assure that the intervention strategy can lead to sustained behavioral change in young child feeding practices among poor rural households.
- Enhanced utilization of vitamin-A rich foods for young children clearly established;

- Improved child-feeding practices and modified preparation techniques to prevent nutrient loss;
- A range of social marketing strategies (e.g. village theater, radio, advertising on buildings in small rural towns) tested for their ability to raise demand for and knowledge concerning the use of orange-fleshed sweet potato in Mozambique.
- Impact of intervention verified through improved serum retinol status.

Objective 4. Improved Access to Income and Knowledge by Caregivers

- Significantly improved nutritional knowledge among women and men.
- Completed feasibility studies on the costs and benefits of introducing income-generating activities based on processed products utilizing sweet potato and other beta-carotene-rich foods and techniques of solar drying;
- Careful analysis of any major shifts in workloads and decision-making responsibilities, particularly those of caregivers, as a consequence of modifying behaviors in response to project interventions.

Objective 5. Development of a Network of Practitioners in the Consultative Approach and Capacity Strengthening in Consumption Analysis

- Trained provincial and district level nutrition and agricultural technical staff on nutrition-related issues, including post-harvest preparation techniques needed to obtain the maximum benefit from the introduced pro-vitamin-A rich cultivars
- One trained national level Ministry of Health/Nutrition division counterpart in food consumption research and other related tools of policy analysis related to improved food security and nutritional status
- Dissemination of comprehensive educational materials on nutrition and food security to agricultural and nutrition extension staff and relevant school personnel.

Objective 6. Cost-Benefit Analysis and Impact Evaluation of Proposed Intervention as Basis for Future Scaling-Up

- A detailed analysis of the array of the potential benefits from this intervention, the impact of the project in the study areas, with a well-developed framework for subsequently analyzing the costs and benefits of scaling-up activities over a larger area in the subsequent follow-up project.

If these goals are achieved, there should be an increased intake of foods that are good sources of vitamin A among participant households through two mechanisms: increased own production and consumption of fresh sweet potato roots and leaves and other vitamin A rich foods, and through the increased household expenditure on pro-vitamin A rich foods. There are two principal target groups: young children of weaning age (6-24 months in particular) and their mothers. However, because a diverse range of benefits reaching beyond these two target groups

is also expected, relevant information concerning impacts at the household level (for example, year-round caloric availability per capita) and the community level (effectiveness of market promotion strategies) will be gathered.

Methodology

A. Project Setting

The proposed research and development intervention will be added on as a component of the Ovata Development Activity Program (Ovata DAP) in 2 of the 10 districts (Mopeia and Namacurra) in Zambézia province where World Vision intends to initiate a 5 year program as of October 2001[8]. In addition to exhibiting high levels of chronic undernutrition of children under five years of age, the area has a high prevalence of *konzo* or spastic paraparesis, an incurable, disabling diseased associated with a monotonous diet of bitter cassava that has not been adequately processed to remove sufficient amounts of cyanogens. Moreover, lack of diet diversity is a recognized problem by provincial level health officials. The Ovata Program has four main objects: 1) increase food security through agriacultural production and marketing through developing marketing groups; 2) improve access to markets and improve infrastructure; 3) increase utilization of production through an integrated nutrition program, and 4) decrease the negative impact of HIV/AIDS on food security through an extensive awareness campaign.

Zambézia is the most populous province in Mozambique, with about 20% of the country's total population. The size and composition of Zambézian households has been heavily impacted by the war and the AIDS epidemic, emphasizing the urgency of empowering women to improve the food security situation of their households. Average household size is only 3.95 in Zambézia, principally due to the dearth of males in the 15-49 age category. As shown in Table 2, the male-to-female ratio for the most economically active age group (15-49 years) is 0.84. Approximately half of Zambézia's population is either under 15 years of age or above 59 years old, placing a substantial burden on economically active adults.

Ten of the sixteen districts comprising Zambézia, approximately 955,000 people, are included in the Ovata design. The research part of sweet potato project will focus on a sub-sample of communities in two districts. However, the results from this work will be incorporated into the integrated nutrition program which will be expanded to all ten districts during the five year period. Thus, the scaling-up of the tested intervention component can readily occur.

[8] World Vision has already been operating in Zambézia during the past 6 years, including in one of the selected intervention districts (Namacurra). Moreover, World Vision has been involved in orange-flesh sweetpotato varietal testing in Zambézia since 1998 and established a multiplication plot in May 2001 in the proposed districts to accelerate implementation.

Table 2. Male-to-Female Ratios for Zambézia Province by Age Group

Age Group	Male/Female Ratio (1997)
<1	0.97
1-5	0.98
6-9	1.01
10-14	1.15
15-49	0.84
50-59	0.96
>=60	1.27
TOTAL	0.94

Two of the major activities to be undertaken within this project are of particular relevance. First the project aims to enhance food security through promotion of alternative staple food, cash crops, and vegetable crops, with the goal of raising rural incomes by 15% while improving diet quality. Second, the project intends promote the appropriate processing and increased marketing of cassava products and rice to major urban centers in Zambézia province, providing a much needed source of value-added income to rural women, the principal cassava and rice producers.

Orange-fleshed sweet potatoes are not only a logical alternative staple food within this project's framework, but relevant cassava processing equipment (chippers, graters, dryers) can also be used with sweet potatoes. Given the promising results obtained for sweet potato flour and other sweet potato processed products with high beta-carotene content developed and tested in Kenya and Uganda (Hagenimana et al. 1999a), the sweet potato component can easily be included in the overall extension package.

The sweet potato project will substantial strengthen the nutrition intervention component of the Ovata DAP, providing resources to undertake a comprehensive baseline survey on household level consumption patterns and frequency of intake of vitamin A rich foods, young child vitamin A status, follow-up diet diversification monitoring and evaluation surveys, plus develop through the consultative research process appropriate vitamin A enriched processed products and a extensive nutrition promotion campaign at the community level. The sweet potato component will help ensure that this intervention aimed at improving overall household food security also will positively impact young child nutritional status.

B. Existing Situation and Potential Direct and Indirect Impact

World Vision Mozambique (WV-Moz) has been working in Zambézia Province for over six years. Since 1996, they have managed the Development Activity Program (DAP), which focuses on increasing household income through cash crop sales. Roots and tubers have received little attention under this framework, as they are principally considered crops produced predominantly for home consumption. The high incidence of *konzo* in Nampula and Zambézia provinces stimulated research to be undertaken by the Nutrition Division of the Ministry of

Health and the subsequent decision to include agro-processing and diet diversification in the design of World Vision's Development Programs in these two provinces.

Namacurra and Mopeia Districts provide distinct agro-ecological settings for testing the use of orange-flesh sweet potato as an entry point for advocating behavioral change in child feeding practices and diversified utilization of the crop. Namacurra (population 161,000) lies in the coastal zone of Mozambique reknown for commercial copra production and where sweet potatoes are grown year-round[9]. Mopeia (population 72,000) lies further inland, where rice and cashew are major crops, and sweet potato is predominantly grown in the lowland areas following the harvest of the major rice crop. Staggered planting and out-of-ground storage of sweet potato will have to be part of the agronomic/post-harvest components undertaken in Mopeia district. The control group for the study will be drawn from a district close to the two intervention districts (Nicoadala) or an isolated area identified in one of the intervention districts.

Current production figures for sweet potato in Zambézia will only become available when agricultural census data are published in 2002. However, the potential direct and indirect benefits of increased pro-vitamin A supply are enormous, particularly considering the small areas of cultivation required to meet minimal daily consumption levels. Table 3 summarizes the average composition of the population of Zambezia with the corresponding recommended daily intake (FAO, 1988) of Retinol Equivalents (RE) of vitamin A required for each age group. An "average" household size of 3.95 reflecting this composition would require 2082 RE of vitamin A per day. Given that 100 grams of orange flesh sweet potato will provide on average 455 µg RE (taking 35% loss of beta-carotene during cooking into account), a family would only need to plant a total 227 square meters of sweet potato over the course of a year.[10] If emphasis is placed on producing sufficient orange flesh material to meet the needs of the most at-risk groups for vitamin A deficiency (children under 6 and pregnant and lactating women), a mere 80 square meters of sweet potato would meet annual recommended minimum intake levels (refer to Table 4). If all households in the two research districts were to plant this amount, the total area under sweet potato need to meet 100% of RDA would be 468 hectares, potentially directly impacting 87,000 persons most at risk. Moreover, the scaling-up of the intervention to all ten districts could eventually impact 341,000 persons most at-risk.

As the rough analysis above indicates, the potential contribution of orange-flesh sweetpotato to the available vitamin A supply is enormous. However, as the conceptual framework emphasized, the sweet potato intervention is part of an entire package of behavioral change that includes increased consumption of a variety of sources of vitamin A, either through own production or purchase. Sales of fresh sweet potato or sweet potato products can also

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[9] In the lowland coastal areas of Zambézia, sweet potato is planted in September-October, January-February, and in June. In Upland areas of Zambézia, the major planting season is in January with a small second planting in river valleys in June (Brian Hilton, World Vision Project Manager, personal communication).

[10] Assuming average sweet potato production of 10 tons/hectare, with 10% post-harvest lost, and 26% weight loss due to peeling.

Table 3. Size and Composition of Population by Gender and Age-Group in Zambézia Province, Census Data 1997[1]

Age Group (Years)	Male			Females		
	Total Number	% of Total Population	RDA: Retinol Equivalent (RE)[3]	Total Number	% of Total Population	RDA: Retinol Equivalent (RE)[3]
<1	53.887	1.9	350	55.684	1.9	350
1-5	285.100	9.9	400	290.433	10.0	400
6-9	151.679	5.2	400	150.857	5.2	400
10-14	173.955	6.0	550	150.639	5.2	550
15-49: npnl[2]	619.086	21.4	600	386.310	13.4	500
15-49: pregnant		0		115.672	4.0	600
15-49: lactating		0		231.345	8.0	850
50-59	60.645	2.1	600	63.064	2.2	500
>=60	57.897	2.0	600	45.556	1.6	500
TOTAL	1402.249	48.5	TOTAL	1489.560	51.5	

[1] All figures are from the 1997 Census, except for those for pregnant and lactating women. The number of pregnant women was estimated to be 4% of the female population 15-19 years of age. The number of lactating women was estimated at 12% of the female population 15-19 years of age.

[2] npnl: non-pregnant, non-lactating

[3] Recommended Daily Allowances (RDA) for Vitamin A by FAO, 1988.

Table 4. Population At-Risk and Required Area under Orange-Flesh Sweet Potato (OFSP) in Districts in World Vision Project for Sweet potato Distribution in Zambézia to Meet RDA Requirements (FAO, 1988) for Vitamin A

					At-Risk Population			Required Annual Retinol Equivalent for At Risk Population	Total Hectares OFSP for at Risk
District	Total Population (1997)	Men	Women	No. House-holds	<6 Years	Pregnant + Lactating Women	TOTAL at Risk Population		
Direct Impact									
Mopeia	71,535	34,914	36,621	18,110	16,954	8,584	25,538	4,817,345,738	144
Namacurra	160,879	76,318	84,561	40,729	38,128	19,305	57,434	10,833,994,058	324
Indirect Impact									
Nicoadala	198,451	97,823	100,628	50,241	47,033	23,814	70,847	13,364,186,468	399
Inhassange	87,396	41,093	46,303	22,126	20,713	10,488	31,200	5,885,465,130	176
Alto Molocue	185,224	89,551	95,673	46,892	43,898	22,227	66,125	12,473,447,220	373
Lugela	106,770	49,739	57,031	27,030	25,304	12,812	38,117	7,190,158,725	215
Gile	126,988	62,383	64,605	32,149	30,096	15,239	45,335	8,551,689,390	256
Gurue	197,179	96,675	100,504	49,919	46,731	23,661	70,393	13,278,526,808	397
Morrumbala	243,751	119,115	124,636	61,709	57,769	29,250	87,019	16,414,801,718	491
Namarroi	95,257	43,280	51,977	24,116	22,576	11,431	34,007	6,414,844,523	192
TOTAL	**955,169**	**460,743**	**494,426**	**241,815**	**226,375**	**114,620**	**340,995**	**64,323,468,383**	**1,923**

contribute to household income, enhancing the ability of caregivers to purchase a more diversified diet. Therefore, the potential impact of the project includes measures of the benefits accruing to households from empowering caregivers to care for their families through increased knowledge, enhancing year-round caloric intake, improving family income, etc.

C. Proposed Interventions

The proposed interventions build on the experience and understanding gained from a pilot project in Western Kenya (Low et al. 1995),(Hagenimana et al. 1999b). In order to provide critical information on the minimum number of home visits that are essential for assuring sustained adoption of the new food habits, the intervention design will carefully document the process of information dissemination and evaluate the efficacy of the timing of the intervention delivery.

Intervention Package 1
1. Provide adequate material and training to farmer's groups (principally women) to ensure access to improved HBCR varieties. No home visits.
2. Educate farmer's groups on adoption of the process of chipping freshly sweet potato, drying and storing chips for later consumption or sale. No home visits.
3. Nutrition education and behavior change targeted to farmer's groups to modify food habits and child feeding practices. Social marketing campaign to reinforce changes. No home visits.

Intervention Package 2
Same as intervention package 1, but in addition to, activities 1-3 for farmer's groups, individual households will receive a home visit from extension personnel every two months.

Control Group
Matched to two intervention groups as closely as possible in terms of socio-economic status, but will receive no intervention until the last few months of the project, when sweet potato vines will be introduced.

D. Sampling Design

Sample size determination will be finalized once all partners are in agreement on the key research hypotheses and following consultation with statisticians. It is likely that there will be 20-30 farmer's or church groups will be randomly selected for each intervention (for a total of 40 to 60 farmer's groups), and within that between 15-20 households randomly selected per farmers' or church group. The estimated number of households in the baseline and follow-up surveys will be 750 households, 250 per group studied. Data for approximately 220 households will provide sufficient power to detect differences between groups in the major outcome variable, serum retinol status, under community conditions, while an additional 30 households will guard against loss of significance due to participant drop-out.

For each selected farmer's group, a list will be made of all households within the group having at least one child 8-24 months of age. Prior to randomly selecting households from the list, project personnel will carefully explain what is involved in the study (including the blood

sampling, likely to be the most difficult part of the intervention), the types of data to be collected, and assure confidentiality of all results obtained. Potential participants will be informed that participation is strictly voluntary and that they can leave the study at any time. The consent protocol will be submitted to the Ministry of Health for approval prior to recruting participants and informed consent procedures will be followed.

While only 750 households will be included in the focused research sub-sample, all households within the larger Ovata project area will be given access to the new varieties before the end of the project period.

The active participation of the Nutrition Division in the project will assure that a sensible, agreed upon protocol is devised regarding potential confounding of the research results due to vitamin A capsule distribution. Mozambique just completed (May of 2001) its second round of vitamin A capsule distribution. This was the last time that capsules will be distributed in a massive campaign. Henceforth, they are going to be distributed at health clinics. Any prophylatic capsule distribution will be discontinued during the course of the study (a maximum of two years) in the localities where study households are located (not all localities in the study district). If the baseline analysis of blood serum levels indicates a high percentage of children with extremely low serum retinol levels, the study protocol will be altered to protect the child. Under this revised protocol, all sub-sample children will receive one vitamin A capsule and the behavioral change sweetpotato-based intervention will be judged for it's ability to maintain adequate levels of serum retinol status throughout the study period.

E. Implementing Partners

The nature of the project requires collaboration between research and implementing agencies, government and non-governmental institutions, farmers and extensionists, health personnel and agricultural personnel. The proposed contribution of each of the major collaborators is briefly described in this section.

The **Nutrition Division of the Ministry of Health** is a key Mozambican institution for determining policy regarding strategies for assuring food security and reducing micronutrient deficiencies. In this project, the division would be responsible for coordinating the development of much of the training material to be used at both the provincial and national level by extension staff, and organizing relevant workshops. The division would collaborate with other partners in designing the research protocol and one member of the division at the national level would participate in all phases of research design and analysis with the goal of producing an analyst within the division capable of doing food consumption analysis and implementing nutrition initiatives to change feeding and eating behaviors. The division would collaborate with the non-governmental organizations, Helen Keller International, and potentially other institutions in the testing and developing of training materials and coordinate the future expansion of intervention activities into provinces outside of area covered by the present project.

Michigan State University has been providing technical assistance in market price analysis, food security research, and policy formulation to the Ministry of Agriculture and Rural Development in Mozambique since 1989. A researcher from **Michigan State University** would be responsible for managing project funds and co-ordenating activities among the different collaborators. MSU will have the primary responsibility for designing a research component in

collaboration with the Nutrition division so as to be able to effectively document the benefits, constraints, and costs of the intervention. In addition, MSU would play a major role providing technical assistance in the capacity strengthening activities, especially regarding the training of the policy analyst and the extension personnel in consultative research.

Since the early 1990s, **World Vision International (WVI)** has been implementing programs with the overall goal of sustained improvement in household food security in several Mozambican provinces, including Zambézia and Nampula. Zambézia province has been selected because of suitable sweet potato growing conditions, and because it contains approximately 20% of Mozambique's rural population and exhibits high levels of child stunting. Creating a partnership with World Vision, which has already developed good working relations within the districts where they work, will facilitate project implementation. Working in close collaboration with provincial and district level Ministry of Agriculture and Nutrition extension agents, WVI will provide the infra-structure and additional extension staff for the project to function.

Helen Keller International (HKI) is an non-governmental organization specializing in research and program activities to understand and combat vitamin A deficiency. HKI will work closely with the Nutrition Division in developing communication and social marketing materials related to nutrition and in expansion of project-related activities throughout the country. At the national and provincial level, HKI will take the lead in promoting vitamin A-related activities in the local media and assist the Nutrition Division in co-ordinating relevant workshops. The organization will provide technical backstopping on issues related to designing effective social marketing campaigns and behavior change research related to improved child feeding practices.

The **Roots and Tubers Program of the National Institute for Agronomic Research (INIA)**, with technical and financial support from the **Southern African Root Crop Research Network (SARRNET)**, will be responsible for transferring materials to be used in the varietal trials of orange-fleshed sweet potatoes. INIA will also be responsible for supervising the agronomic training of technicians of collaborating non-governmental technicians and agricultural extension personnel in testing new varieties of sweet potatoes and on rapid multiplication techniques for planting material.

SARRNET is a regional network for the Southern African Development Community (SADC) countries, implemented jointly by SACCAR (the agricultural research branch of SADC), the International Institute of Tropical Agriculture in Nigeria (IITA) (which supports project management and provides backstopping and training on cassava) and the regional office of the International Potato Center in Nairobi (CIP) (which provides backstopping and training on sweet potato). Links with SARRNET assure that results from the project will disseminate to agricultural researchers in other SADC countries. Moreover, CIP will provide additional scientific information on agronomic issues and process product development, and assist with the global dissemination of key findings. INIA/SARRNET will post an agronomist specialized in sweetpotato multiplication and adaptive trial management in Zambézia during the first year of the project period using funds from another source.

The principal and secondary responsibilities of the different collaborators in this project is summarized in Table 5. All partners will be involved in the finalization of the research and intervention protocols. Once the project is underway, monthly meetings will be held with all

Table 5. Summary of Primary Responsibilities of Collaborating Partners

Institution	Brief Description	Responsibilities for Implementation: P=Primary S=Secondary		
		Research	Devel-opment	Capacity Building
Nutrition Division, Ministry of Health (MOH)	Key division in the Mozambican Ministry of Health responsible for national policy on nutrition	S	**P**	**P**
Michigan State University (MSU)	United States Land Grant University specializing in food security and nutrition research	**P**	S	**P**
World Vision International (WVI)	Non-governmental organization operating in Northern & Central Mozambique since 1984	S	**P**	S
National Institute for Agronomic Research (INIA)	National research institute responsible for testing new agricultural technologies	**P**	--	S
Ministry of Agriculture and Rural Development (MADR)	Recently began operating under PROAGRI framework emphasizing smallholder agriculture development to reduce rural poverty	--	**P**	S
Southern African Root Crops Research Network (SARRNET)	Provides technical and financial support to national agricultural programs in SADC countries, with backstopping from IITA and CIP.	S	--	S
Helen Keller International (HKI)	Non-governmental organization focusing on micronutrient malnutrition with extensive field experience in communication techniques and intervention strategies for combating vitamin A deficiency	**P**	S	S

partners to assure the smooth functioning of project activities. At the beginning of the project, and every six months thereafter, key planning and discussion meetings will be held with all stakeholders interested in improved nutritional status through the use of sweet potato.

The MSU research-project director will collaborate with a full-time counterpart seconded from the national level Nutrition Division who will be directly involved in all phases of research and project design, implementation, analysis, and report preparation. Specialized extension and research personnel will be hired by the project to initiate the sweet potato based intervention at the district level. Once effective practices and appropriate processed products have been identified through the consultative research process, MADR and WV extension personnel from

the larger Ovata DAP project will be trained and subsequently will assist in on-going project implementation and evaluation.

F. Implementation Strategy for Achieving Results

Given that it takes 5 months for one round of sweet potato production, it will take two and a half years to achieve the overall goal of the project. A calendar for implementing the project summaries the major activities to be undertaken organized under five distinct categories of results is shown in Figure 2 (refer to attached EXCEL table). These activities are summarized below, highlighting which partners are principally responsible for specified functions. Some of the activities are dependent on having an adequate supply of sweet potato available in the community and hence, priority must be given in the initial stages to introducing varieties acceptable to local communities in terms of taste and yield. World Vision has already initiated research on varietal testing as part of its current project to facilitate the implementation of the proposed project.

Objective 1. Supply of High-Yielding Beta-Carotene Rich (HBCR) Planting Material Assured

As soon as funds are available SARRNET/INIA will assist local MADR and WV extension personnel in the proper selection of sites for establishment of large-scale rapid multiplication plots of HBCR sweet potato varieties within Namacurra and Mopeia Districts. These plots may belong to community or women's groups interested in producing planting material for their areas. Training in proper techniques for establishing rapid multiplication plots will be provided by SARRNET/INIA agronomists. These plots will provide adequate material to ensure that all participating groups/individuals within the selected areas will have access to the improved varieties. Moreover, the existence of a larger site producing sufficient root supply within 5-6 months of the start of the program, will accelerate the development of the social marketing campaign and processed product development. To confirm that the supply of HBCR is maintained and expanded over time, an assessment of the process and rate of informal (farmer-to-farmer) varietal distribution of HBCR material will be conducted towards the end of the survey by MSU, SARRNET/INIA, and MADER. Yields and other major characteristics of the introduced varieties will be evaluated by community members during three growing seasons. SARRNET/INIA will ensure that MADER/WV extension agents follow established procedures for on-farm evaluations.

Objective 2. Reduction in Fluctuation of Calorie Supply from Major Staples and Vitamin A Supply from Plant and Animal Sources

There are three major mechanisms by which seasonal fluctuations in caloric and vitamin A supply characteristic of rural Mozambique is expected to be attenuated: 1) the introduced varieties are higher yielding, thus producing more calories on the same amount of land, 2) farmers in adequate rainfall areas will be encouraged to "stagger" plant, that is, plant some additional sweet potato every month when there is adequate rainfall or residual moisture, and 3) exposure to and adoption of the process of chipping freshly sweet potato (using a manually operated chipper designed in Uganda cuts it into smaller pieces), drying the chips, and safely

storing the chips for later consumption or sale. SARRNET/INIA will train local MADER and WV extensionists on agronomic techniques. They in turn will work with local farmers groups. Processing activities for storage will be part of the training for processed product development to be undertaken by the Nutrition Division in collaboration with WV and MADER extensionists. Monitoring changes in caloric availability at the household level is part of the research/evaluation effort which is described in greater detail in the next section.

Objective 3. Modified Food Habits, Improved Child Feeding Practices, Improved Serum Retinol Status Achieved

A major component of this project intervention is designing a behavior change component and appropriate nutrition education messages for modifying food habits and improving child feeding practices. A critical input into the development of the social marketing campaign is formative research to understand the knowledge, attitude and practices of current food habits and child feeding practices. A variety of research methods will be employed during the development and testing of the nutrition education and behavior change and communication components of this project. Qualitative methods such as in-depth interviews and focus groups will be employed to provide descriptive information about dietary patterns and food preparation, and to identify both the constraints to behavior change and possible motivators or enablers for behavior change. Trials of improved practices (TIPs) will involve mothers in a dialogue concerning practical, acceptable new child feeding behaviors. Data from qualitative and quantitative methods will be compared and integrated in developing an overall education and communication strategy (Helen Keller International (HKI) n.d.).

The social marketing campaign will rely heavily on radio use and dissemination through available community institutions (church groups, farmer's groups). The Nutrition Division in collaboration with Helen Keller International will take the lead in designing and executing bi-monthly campaigns based on findings from the formative research. Women within the groups will be encouraged to become "trainers" of other members.

Both at the beginning and as close towards the end of the project, the vitamin A (serum retinol) status and the frequency of vitamin A rich foods of the 750 selected study children will be assessed. Serum retinol status will be assessed using a more recently developed method where a small amount of blood from a simple finger prick is blotted onto a filter paper and analyzed in the United States (Craft et al. 2000). Given the difficulties of maintaining a cold chain in rural Mozambique and widespread aversion to blood sampling common in Southern Africa, this method is preferred to the more widely used blood serum retinol analysis which requires venal blood extraction and dependable cold chain.

Objective 4. Improved Access to Income and Knowledge by Caregivers

Market development for increasing the commercialization of cassava and cassava products is already a key component of the Otava DAP. Sweet potato root and processed product sales can be easily incorporated under this framework which will be coordinated by World Vision project staff with backstopping from agro-processing specialists provided by INIA/SARRNET in the first year.

MSU will assist WV in assessing the market demand for potential processed products and in evaluating the labor input required for process product development. Special attention will be paid in assessing any changes in workload, particularly for caregivers, that adoption of new processing technologies would require. By the end of the project period, it will be possible to understand the benefits and costs of alternative processed products and assess the degree to which identified products have been able to penetrate major urban markets within the province.

Objective 5. Development of a Network of Practitioners in the Consultative Approach and Capacity Strengthening in Consumption Analysis

Communication and coordination among all proposed partners is the foundation of successful project implementation. The Nutrition Division counterpart will be working on a daily basis with MSU and WV personnel. Broad-based stakeholder meetings will be held twice a year to ensure feedback from researchers, practioners, and farmers associations not directly involved in project managemente. In addition, monthly meetings will be held with all partners to consult regarding design and implementation issues.

Emphasis will be given to producing manuals and other communication material that can be used both within the current project and during the subsequent two and a half years of the Otava DAP. HKI and the Nutrition division will have principal responsibility for writing a manual on how to develop culturally appropriate communication materials. SARRNET/INIA and the Nutrition Division will take the lean in developing a manual for rural development extensionists. MSU, the Nutrition Division, and WV will be responsible for providing all project documentation and research reports. The will also determine appropriate indicators which can be used to monitor future larger-scale expansion efforts. The final workshop, to be held in April 2004, will emphasize the dissemination of best strategies found for assuring the rapid adoption of the new technology and methods for assuring sustained behavioral change.

Result 6. Cost-Benefit Analysis and Impact Evaluation of Proposed Intervention as Basis for Future Scaling-Up

Quantitative research methods will be used to evaluate the effect of the intervention on key outcome variables for the first four results as described above. The impact evaluation will require a baseline and follow-up survey in the study areas, to be described in greater detail below. These surveys will be used to understand the underlying causes of vitamin A deficiency, as well as evaluate the impact of the intervention on increasing the supply of HBCR (result 1), on increasing and stabilizing the household food supply of total calories over several seasons (result 2), on modifying food habits, improving child feeding practices and increasing nutritional status measured by serum retinol levels (result 3), and improving access to income and knowledge by caregivers (result 4). A key premise of the intervention design is to improve our understanding of the process of how to successfully modify food habits and child feeding practices and sustain those behavior changes. This is one of the most difficult parts of the proposed project and the one which requires the most carefully developed research component.

During the formative research stage to develop the behavior change and communication strategy (see result 3), a quantitative survey data on dietary intake (emphasizing diversity

measures), knowledge and practices regarding food and child feeding will also be gathered. According to a recent review of food-based strategies to reduce vitamin A and iron deficiencies, "Questions on the efficacy and the effectiveness of food-based approaches remain largely unanswered" (Ruel and Levin 2000). Evaluation designs to date have not allowed firm conclusions to be drawn about the impact of food-based interventions on vitamin A status. In part, this is because one must measure multiple indirect as well as direct effects that complicate the research design and thus, increase overall cost. During the first month of the project, the research partners will develop and pre-test a comprehensive baseline survey to cover all selected households, with the aim of being able to capture any significant changes in vitamin A status, consumption patterns, feeding practices, women's labor use patterns, and income sources and uses which occur. To capture both direct and the multiple indirect effects, it is highly probably that the survey will include the following components described in Table 6.

The detailed consumption/expenditure data will be used to develop a dietary model based on frequency of consumption to predict levels of household intake of calories and vitamin A, along the same lines as that developed by (Ruel and Levin 2000). This model will be used to monitor changes in per capita household level consumption of calories and vitamin A throughout the year based frequency of consumption indicators.

Since intake of calories and vitamin A is particularly critical in the "hunger" season from December through February (the period when planting has been completed, but there is nothing yet to harvest to re-fill depleting stocks), emphasis will focus on monitoring diversity in sources of vitamin A during the hungry seasons of 2002 and 2003. Overall household caloric intake will be assessed at the beginning of the harvest season in 2002 & 2003. In addition, the HKI food frequency methodology capturing vitamin A intake among young children will be repeated both in the "hunger" season and the post-harvest season (twice a year for two years) along with group interviews to capture seasonal variations in consumption and detect any emerging bottlenecks to assuring sustained change in dietary patterns.

G. Data Analysis

All quantitative data analysis will be done using the most recent version of STATA. MSU will train the Nutrition Division counterpart in whatever statistical and applied regression procedures are required as part of in-service training. The Zambézia field office will require four computers and one laser printer. At the end of the project, these will become the property of the Nutrition Division.

Table 6: Description of data modules, level of collection and timing of collection

Type of Information	Level of collection	Number of Rounds			
		Round 1 Baseline Hunger Season	**Round 2**	**Round 3**	**Round 4 Final Evalu-ation**
1. Demographic information and background information on education	Household, individuals	✓	✓ **Demographic only**	✓ **Demographic only**	✓ **Demographic only**
2. Food and non-food expenditures; 24- hour recall	Household		✓		
3. Dietary Diversity Index based on consumption Data	Household			✓	✓
4. HKI frequency survey for young child vitamin A intake	Individual (6-24 month old children)	✓	✓	✓	✓
5. Agricultural production, current sweet potato yields and land tenure relations	Households	✓	✓	✓	
6. Past income and assets	Household by Gender	✓			✓
7. Agricultural wage labor, & other sources of income; labor patterns (including transfers)	Individual	✓		✓	
8. Infant and child feeding practice, care practices and nutritional knowledge of mothers, fathers or principal caregivers.	Individual	✓	✓	✓	✓
9. Anthropometry and vitamin A status (serum retinol levels using dried blood spot method)	Individual (6-24 month old children)	✓			✓
10. Use of health infra-structure	Household Community	✓	✓	✓	
11. Market research	Community			✓	✓
12. Cost Benefit Analyses	Household				✓

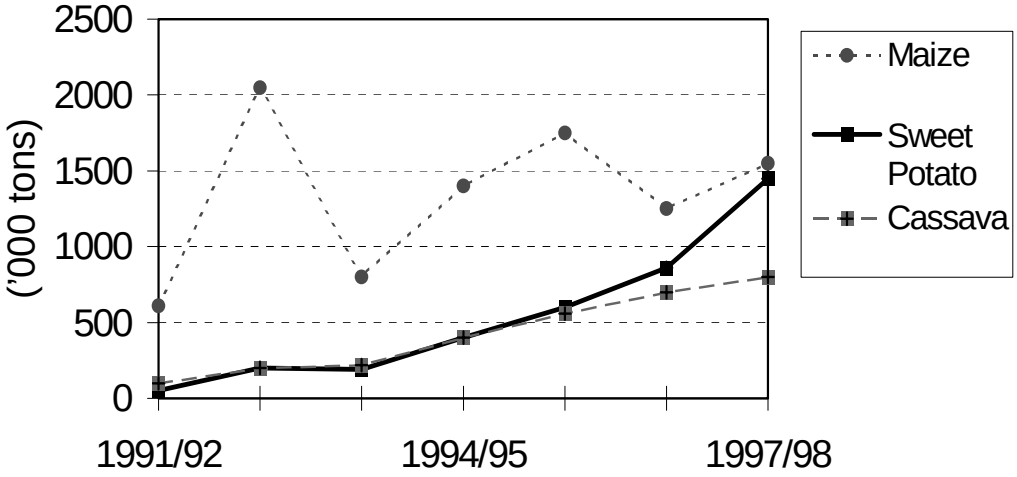
Relevance of the Findings and their Dissemination

Given that the number of children in Sub-Saharan Africa affected by chronic malnutrition (stunting) increased by an alarming 62% between 1980 to 1995 (United Nations 1997), the need for addressing malnutrition on the continent is acute. The use of improved, higher-yielding food crops and increased incomes for purchasing better quality diets and improved health care is critical to address this situation. Sweet potato is grown in every country south of the Sahara (Scott and Ewell 1992). Moreover, several Eastern and Southern African countries have witnessed major increases in sweet potato production in the 1990s (Scott and Maldonado 1999). The most dramatic increase has been seen in drought-prone Malawi, where a concerted effort by government and international agencies to massively distribute improved varieties of cassava and sweet potato has been underway since 1993/94 (Figure 3). By 1997/98, annual per capita consumption of sweet potato had risen to 79 kgs, with sweet potato rapidly emerging as a major food staple alongside maize. Unfortunately, no beta-carotene rich varieties were included in this distribution effort.

Higher yielding, early maturing varieties with significant beta-carotene content address the need for enhanced diet quality as well as improved calorie availability. Because of the poor health infra-structure and limited financial resources of many poor rural households both within and outside of Sub-Saharan Africa, it is critical that alternatives to supplements and fortification are explored. If findings from the proposed research demonstrate that improvement of dietary quality through the introduction of an agricultural technology combined with a set of improved child feeding practices is a cost-effective and *sustainable* approach for reducing vitamin A deficiency, the transferability of these findings to other settings is likely to be high.

A workshop will be held at the end of the project period to disseminate results from this work. Moreover, given the extensive size of World Vision's and other NGO activities in Northern and Central Mozambique, it is likely that incorporation of the sweet potato component into other provinces will begin even before the closure of the project period. As sweet potatoes are being distributed as part of the emergency release in the southern part of the country, approaches and materials developed for improving the young child diet will be distributed to interested organizations as soon as they are available. On-going sweet potato varietal testing by INIA/SARRNET in other provinces will be continuing during the project implementation phase, thus setting the groundwork for a follow-up project to massively scale-up the best intervention emerging from this study to the national level.

Figure 3. Trends in Sweet Potato, Maize and Cassava Production in Malawi, 1991/92-1997/98



Source: Ministry of Agriculture and Irrigation (FEWS), Malawi as cited by Phiri, 1998

Budget Request

Please see attached budgets in the total amount of US$1,180,474.

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OVERALL BUDGET

WORLD VISION BUDGET

HELEN KELLER INTERNATIONAL BUDGET