THE POTENTIAL CONTRIBUTION OF A SUSTAINABLE ORGANIC HOUSEHOLD FOOD GARDEN TO VITAMIN A AND VEGETABLE NEEDS OF SAMPLED LOW-INCOME HOUSEHOLDS, KWAZULU-NATAL.

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ABSTRACT

Vitamin A deficiency is a worldwide public health problem. In South Africa, in 1999, 62 to 70 percent of children in rural areas and 48 to 62 percent in urban areas consumed less than half the recommended dietary allowance for vitamin A. This study set out to investigate the potential contribution of home gardens to the vitamin A and vegetable needs of low-income households, especially in rural areas. The study problem was to develop a model of a sustainable household food garden to ensure adequate supply of vitamin A rich vegetables to meet the vitamin A requirements of low-income households throughout the year. The study subproblems included: first, to develop an organic household food garden unit to provide adequate vitamin A and vegetables for households. Second, to test the feasibility of the garden unit among sample households in two study areas. Third, to test vitamin A and vegetable adequacies of the garden unit for the sample households.

A survey of 52 households from Department of Agriculture communal garden projects in Cuphulaka and Mlwandle in KwaZulu-Natal was conducted. The sample households were participants in communal gardens, but the survey dealt with household production only. Data included household demographics, types of vegetables grown, garden sizes, gardening practices, the socio-economic and environmental constraints of home gardening and the food frequency consumption. The garden unit was developed from a review of literature regarding best practice of organic production of vitamin A rich vegetables. The garden unit was demonstrated to the study participants and their perceptions of the unit were measured in discussion groups to test the acceptance and feasibility of the household garden. Data on household demographics and frequency of vegetable consumption was used to measure adequacy of vitamin A consumed by households and to test adequacy of vitamin A and vegetables from the garden unit.

Most participants depended mainly on communal garden projects for vegetables. Although access to land seemed not a problem, few sample households practiced home gardening. Water scarcity and lack of fencing were frequently reported as constraints of home gardening by sample households who perceived home gardening as a cost-effective way of diversifying and adding nutrients to family diets. However, vegetable production in home gardens was characterised by low yields and seasonal availability. The potential of the household food gardens to increase vegetable production was found feasible by sample households.

No significant difference was identified in vegetable consumption of households with and without home gardens. In fact, participation in communal gardens does not increase the vegetable consumption of sample households, which may be the result of no or low production and poor eating habits. The study assumed that rural households should consume at least 33 percent of RDA of vitamin A from vegetables, yet many sample households consumed less than this. Sample households could obtain enough vitamin A and vegetables from the garden unit/s, and in many cases they could have surpluses. Recommendations include the integration of home gardening in government strategies and integration of nutrition education in programmes that aim at increasing vegetable production in communal and home gardens in study areas.

DECLARATION

I hereby declare that the research reported in this dissertation is of my own investigation. Where use has been made of the work of others, this has been duly acknowledged in the text.

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My mother, 'Mamatsoso Makhotla, my father, Thabo Makhotla, my brothers and sisters

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CHAPTER 1

THE PROBLEM AND ITS SETTING

1.1 Introduction to the research problem

Food security implies access to enough food, energy and nutrients for all people of all ages, in all seasons for a healthy and productive life (World Health Organisation (WHO) 2000). Food security occurs at national, local, household and individual levels to ensure adequate individual dietary intake (Gittinger *et al.* 1987). However, food available at national or local levels does not guarantee enough food for every household (Frankenberger and McClaston 1998, Almagir and Arora 1991, Maxwell 1995). Access to nutritionally adequate and safe food at all times is a basic human right (WHO 2000). Yet poor households, especially in rural areas, often do not consume balanced diets (Ruel and Levin 2000). Low-income households live on staple-based diets low in micronutrients, particularly vitamin A (Ruel and Levin 2000).

Vitamin A is essential for good eyesight, a healthy immune system and the growth and development of children (Food and Agriculture Organisation (FAO) 1992). Vitamin A deficiency is common among young children, pregnant women and lactating mothers in low-income countries (WHO 2000). The implications of vitamin A deficiency among children include: night-blindness, corneal scars, increased morbidity, stunting, and if not treated, vitamin A deficiency can lead to childhood blindness and death (Ruel and Levin 2000, FAO and International Life Sciences Institute (ILSI) 1997). Pregnant women and lactating mothers are more vulnerable to vitamin A deficiency as their demands for vitamin A increase to provide stores for the growing foetus and infant respectively (Nutrition Information Centre of University of

Stellenbosch (NICUS) undated a). Vitamin A deficient women and children are also more vulnerable to anaemia, which is the disorder of iron deficiency responsible for reduced physical strength and low productivity in affected populations (Hanekom and Kruger 2002). Hence many governments and international agencies prioritise elimination of vitamin A deficiency among vulnerable households (FAO 1997).

More than 250 million people worldwide are affected by vitamin A deficiency (FAO 1997). Between 250,000 and 500,000 children in developing countries become partially or totally blind each year as a result of vitamin A deficiency and about two-thirds of these children die within 12 months of losing sight (FAO and ILSI 1997). At least 52 million African children are at risk of vitamin A deficiency while about one million African children show clinical signs of vitamin A deficiency (FAO 1997).

In 1994, about 33 percent of South African children aged six to 71 months had low serum retinol levels and non-urban children were more affected than urban children (Bonti-Ankomah 2001, de Hoop *et al.* 2002). Twelve percent of South African children aged six to 71 months were nightblind and 18 to 43 percent of the same age group had low levels of vitamin A in 1994 (Opportunities for Micronutrient Interventions Project (OMNI) 1998). The prevalence of vitamin A deficiency is severe in eight of South Africa's nine provinces (de Hoop *et al.* 2002). Vitamin A deficiency is highest among children in Limpopo Province, KwaZulu Natal, Mpumalanga, North West Province and Eastern Cape Province (Steyn 2000).

Literature (Marsh 1998, Nell *et al.* 1999) has shown that vegetable production in household gardens is a cost-effective nutrition intervention that is culturally acceptable and often effective in increasing supply of vitamin A rich vegetables in a sustainable way. As vitamin A supplementation programmes in low-income countries have not been effective, are more difficult to manage than was anticipated by governments, are expensive and do not reach many areas because of lack of all weather roads, food-based strategies seem to offer more effective mitigation for vitamin A deficiency (Marsh 1998, Ruel and Levin 2000, FAO 1997, and FAO and ILSI 1997). Although home gardens may contribute significantly to household food and nutrition security (Marsh 1998), many African households do not produce enough vegetables on available land (FAO 1995a). Little information is available globally and in Southern Africa to demonstrate that there is a link between cultivation of vegetables, increased vegetable consumption and improved nutritional status (Webb 2000).

In this study, a metre square household garden unit is designed to use organic farming practices (such as successive cropping, crop rotation, crop diversification and soil composting) to increase variety of selected vitamin A rich vegetables. This pilot study assesses whether this organic garden unit can ensure sustainable production of a variety of vitamin A rich vegetables on a small piece of land to meet vitamin A needs of low-income households. The study aims to provide information on the contribution of organic gardens to the vitamin A and vegetable needs of low-income households for policy makers, development planners, agriculturalists and nutritionists so that strategies aimed at increasing the production of vitamin A rich vegetables are supported.

1.2 Research problem

To develop a sustainable household food garden unit to ensure an adequate supply of vitamin A rich vegetables to meet the vitamin A requirements of low-income households throughout the year and to investigate household perceptions of the feasibility and acceptance of the garden unit.

1.3 Sub-problems

Sub-problem 1: To develop a simulated organic household garden unit to provide adequate vitamin A rich vegetables for households.

Sub-problem 2: To test the feasibility and acceptance of the garden unit among sample household representatives in two study areas.

Sub-problem 3: To test vitamin A and vegetable adequacy of the garden units for the sample households.

1.4 Hypotheses

Gardeners in Cuphulaka and Mlwandle communities will accept the organic garden unit and find it feasible to ensure sustainable production of a sufficient variety of vitamin A rich vegetables to meet household vitamin A requirements throughout the year.

1.5 Conceptual framework

Figure 1.1 illustrates the relationships between variables that are included in the research problem and the sub-problems under investigation. The availability of gardening inputs and practice of organic gardening influence year-round production of vitamin A rich vegetables, which in turn increase security of vitamin A among households. The role of the socio-economic and environmental factors in vegetable production is discussed in section 2.4.

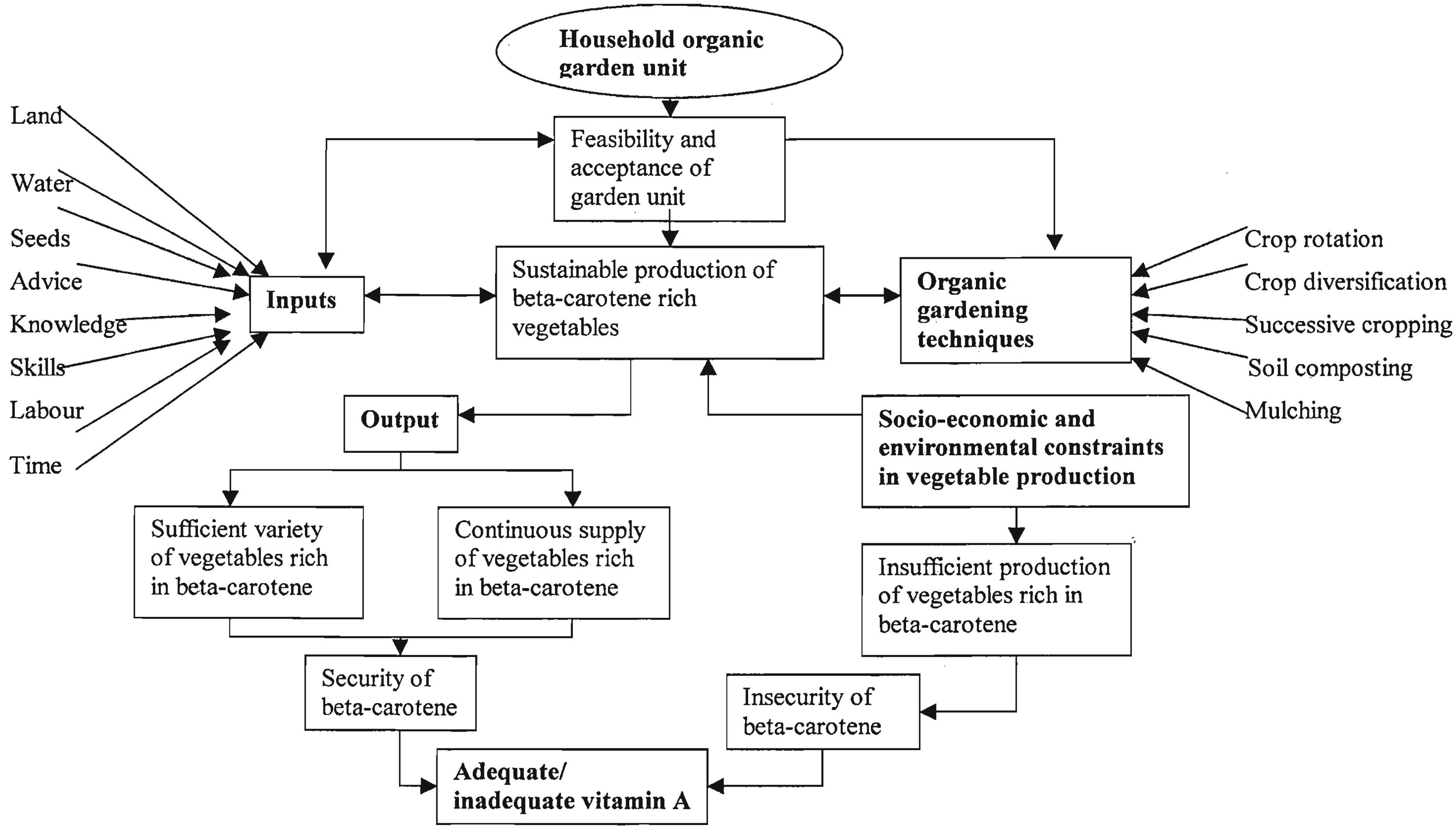

Figure 1.1 The conceptual framework of the study problem

1.6 Delimitations

The study has four delimitations. First, although availability of income and vegetable markets may increase supplies of vegetables that are rich in vitamin A, this study only focussed on vegetable production as an indicator of vegetable security in the study areas. Second, vitamin A status of household members was not measured. This study only measured the potential of selected vegetables in satisfying daily vitamin A needs of household members as expressed in Recommended Dietary Allowance (RDA) tables (FAO 2001) and assessed frequency of vegetable intake by household members. Third, biochemical analysis of the vitamin A content in selected vegetables was not conducted, but assessment of vitamin A contents of vegetables was based on food composition tables (Gouws and Langenhoven 1986, Blum *et al.* 1997 and FAO 2001). Fourth, the garden unit was not implemented, only the feasibility and acceptance of the concept among sample households were measured.

1.7 Assumptions

The study had three assumptions. First, it was assumed that households are interested in gardening and would therefore offer to participate in the study. Second, the study assumed that the study participants were honest about their perceptions of the acceptance and feasibility of the garden unit. Third, data collection tools were designed in English and translated into Zulu. Answers were recorded in English for analysis and interpretation. Therefore, the study assumed that data translation from English to Zulu and from Zulu to English was done accurately.

1.8 Summary

Vitamin A deficiency is a worldwide public health problem. Africa has the highest vitamin A deficiency especially among children. In South Africa, vitamin A deficiency is highest among children in Limpopo, KwaZulu-Natal, Mpumalanga, North West and Eastern Cape Provinces. The high prevalence of vitamin A deficiency in rural areas may be a result of low production of vitamin A rich foods and poor access to markets that sell fresh and quality vegetables. High prevalence of vitamin A deficiency calls for interventions to overcome this deficiency among vulnerable groups.

Little information is available globally and in Southern Africa, relating food gardens to improved nutrition. More research is required to support the contention that food gardens increase vegetable consumption and improve nutrition of household members. This study designed a household food garden unit of vitamin A rich vegetables for low-income households. The feasibility and acceptance of the garden unit was tested among sample households in the study areas. The vitamin A and vegetable adequacy of the garden units for the sample households was estimated to measure the contribution of the garden to the needs of households.

This chapter has presented the importance of the study, research problems, hypothesis, delimitations and assumptions of the study. Chapter 2 outlines the related literature to portray the prevalence of vitamin A deficiency, people at risk of vitamin A deficiency, the causes and control measures of vitamin A deficiency. Chapter 2 also assesses the possible contribution of home gardens to food and nutrition security in developing countries. The potential of organic production in increasing availability of vegetables in home gardens is also reviewed.

Chapter 3 presents the study design and outlines the sample characteristics. Chapter 4 outlines the design of the garden unit. The feasibility and acceptance of the garden unit by the sample households are presented in Chapter 5. The design of the model to determine vitamin A adequacy of the garden unit is demonstrated in Chapter 6, while the adequacy of vitamin A and vegetables is presented in Chapter 7. The conclusions and recommendations are presented in Chapter 8.

CHAPTER 2

REVIEW OF RELATED LITERATURE

Household food security is assured when households have continuous and stable access to resources for food in terms of quantity and quality, which in the presence of good health, a safe environment and good care translates into good nutrition (WHO 2000). People are food secure when they consume balanced diets that contain carbohydrates, fats, protein, vitamins, minerals and water (FAO 1995a). When dietary intake and balance of these nutrients is inadequate, growth and development of young children and developing foetuses is adversely affected (FAO 1992).

A long-term decline in supplies of food results in poor nutritional status and malnutrition (FAO 1997). Malnutrition in children results in growth retardation and is often associated with reduced physical activity, vulnerability to infections and poor mental development (World Bank 1998). However, low-income households, particularly in rural areas often live on staple-based diets that are adequate in energy and protein, but low in micronutrients (including vitamin A) (Ruel and Levin 2000).

Vitamin A is essential for good eyesight and growth and development of young children (FAO 1992), maintaining the immune system and protecting the body against infections. Vitamin A is also associated with healthy appetites and adequate body weights (NICUS undated a, World Bank 1998). This vitamin is stored in the body and deficiency occurs when vitamin A is depleted, causing physiological malfunctions (Administration Committee on Coordination Sub-Committee on Nutrition (ACC/SCN) 2000), increased incidence of infections, and increase risk of death due to reduced efficiency of the immune system (FAO 1997). Sick people often lose their appetite and this results in poor dietary intake leading to further malnutrition and under-nutrition (FAO 1992). Further, more malnourished children experience higher risk of infections and this results in a malnutrition-infection complex (FAO 1997).

The earliest symptom of vitamin A deficiency is night-blindness, which is poor eyesight in dim light (FAO 1997). If the deficiency is not treated, partial or total blindness, usually identified by corneal scars occurs (WHO 2000), causing death within 12 months of losing sight (Sifri *et al.* 2002, Ruel and Levin 2000). Vitamin A deficiency also results in increased rates of miscarriages, low-birth weights, premature babies and poor absorption of iron among children and pregnant women (ACC/SCN 2000, Hanekom and Kruger 2002).

Low-birth weight babies are at risk of vitamin A deficiency because their body stores of vitamin A are low and they are more likely to be underweight or stunted in early life (Table 2.1) (FAO 1997). Children may experience faltering growth and increased chances of contracting severe infections and illnesses such as diarrhoea and measles if they are vitamin A deficient. A quarter of a million children in developing countries die each week as a result of malnutrition and infections (Nell *et al.* 2000). Chances of mortality also increase when children's diets are low in vitamin A and other micronutrients (ACC/SCN 2000). Infants and young children with recurring infections are vulnerable to vitamin A deficiency because repeated infections increase the body's need for vitamin A.

Malnourished infants and children often consume diets insufficient in nutrients, including vitamin A. Pregnant women and lactating mothers need more vitamin A rich foods to meet the vitamin A demands of the growing foetus and to provide stores for infants at birth respectively (FAO 1997). Children living in rural areas and children from poor households are more vulnerable to vitamin A deficiency than children who live in urban areas and who come from households with better income levels (World Bank 1998). Vitamin A deficiency is a public health problem in 118 countries of which 83 have reported to WHO (ACC/SCN 2000), and 64 have reported to United Nations Children's Fund (UNICEF) (Sifri *et al.* 2002).

Table 2.1 Population segments at risk of vitamin A deficiency (ACC/SCN 2000, World Bank 1998, WHO 2000, Hanekom and Kruger 2002)

Population segments	Implications of vitamin A deficiency
Low-birth weight babies	Likely to be stunted in early life.
Infants and young children	May experience faltering growth, and chances of infections and death increase.
Malnourished infants and children	Further malnutrition may occur and chances of infections and death increase.
Pregnant women	They have to meet the demand of growing foetus.
Lactating mothers	They have to provide adequate stores of vitamin A for infants.
Women and children	May experience higher risk of anaemia.
Children from low-income households	Lack of affordability to purchase vitamin A rich foods.

This chapter begins by highlighting the causes of vitamin A deficiency and presenting the strategies for controlling vitamin A deficiency. The contribution of home gardens to South African food and nutrition security is then reviewed. Factors leading to low production of vegetables in South African home gardens are assessed. Finally, the potential of organic production in ensuring availability of vitamin A rich vegetables that are suitable for home gardens is presented.

2.1 Causes of vitamin A deficiency

There is a strong link between individual food consumption frequency and good nutrition (Maxwell 1995). Poor consumption of vitamin A rich foods (in terms of variety, quantity and frequency) is the immediate cause of vitamin A deficiency (Ruel and Levin 2000, Dunne 1990). Breast milk has sufficient vitamin A (Blaauw 2002) to meet the vitamin A needs of infants under six months old (NICUS undated a). Exclusive breastfeeding plays a significant role in children's vitamin A status (FAO 1997), yet the South Africa Demographic and Health Survey (1998) indicated that only 10 percent of South African infants were exclusively breastfed in the first three months of their life (Department of Health 1998). Among mothers of children aged 12 months and below, who attended clinics in the Limpopo Province, only 7.6 percent of mothers exclusively breastfed their children in the first 4 to 6 months of life (Mushaphi *et al.* 2002). Ninety-seven percent of mothers included in this survey continued breastfeeding beyond six months.

Weaning foods of poor nutritional value are commonly introduced to infants too early, resulting in poor intake of nutrients and malnutrition (FAO 1997). Mushaphi *et al.* (2002) reports that weaning foods were introduced to 19 percent of children in the Limpopo province sample before the age of three months, while only seven percent of children were introduced to weaning foods after seven months.

Low-income households consume mainly staple foods rich in energy and protein but then diets are typically low in micronutrients (Ruel and Levin 2000). In addition to these staples, green leafy and yellow vegetables and fruits are required for micronutrients while milk and meat are required for protein. However, micronutrient-rich foods such as liver and fruits are often expensive, hence children from low-income households become more vulnerable to vitamin A deficiency (World Bank 1998). The 1999 National Food Consumption Survey of South Africa found that children in all provinces reportedly ate bread and margarine daily, with less than one-third of the sample reportedly consuming foods rich in micronutrients such as fruits and vegetables (including vitamin A) (Maunder *et al.* 2001).

Increased consumption of a diversity of foods including micronutrient-rich vegetables is determined by availability of these foods (Sifri *et al.* 2002). Yet subsistence agriculture only plays a small role in the procurement of food, since many South African households depend on supermarkets and local shops for food (Labadarios *et al.* 2001). This implies that many households depend on incomes to acquire foods, making it difficult for low-income households to access micronutrient rich foods (NICUS undated a). Home gardens provide dietary diversity among households through saving income that was previously used to purchase vegetables (Schmidt and Vorster 1995).

The global recommendation for daily consumption of fruits and vegetables is 400g or five portions per day (Love and Sayed 2001). However, the recommended average intake of 400g of fruits and vegetables may not necessarily be appropriate for all population groups such as young children and old people (Rayner 2003). Basiotis *et al.* (2000) and Seals (undated) recommend 3 to 5 servings of fruits and vegetables per day. One cup of cabbage or spinach types equals one serving, while half a cup of carrots or beets equals one serving or approximately 80g (Seals undated).

The findings from the South African Food-Based Dietary Guidelines study conducted in KwaZulu-Natal and the Western Cape (2001) indicated that many households in rural areas eat two meals per day (Love and Sayed 2001). Meals of black rural dwellers consist typically of maize meal and leafy vegetables, wild spinach and pumpkin (Love and Sayed 2001). Women and children in Western the Cape ate more vegetables than men. Approximately 29 percent of black urban dwellers in the Western Cape had not eaten vegetables in the 24 hours prior to the survey. Fruits are typically eaten only when they are available in season. Many South Africans do not meet the recommended daily consumption of five portions of vegetables and fruits (Love and Sayed 2001). Households in the Eastern Cape who produce vegetables do not necessarily consume more vegetables than households who do not produce vegetables (Webb 1996, cited by Webb 2000). Household members in Eastern Cape consumed vegetables two to three times a week and in small amounts (Webb 2000).

Low consumption of vegetables and fruits in South Africa is commonly a result of low incomes among many South African households (Maunder *et al.* 2001). Children's resistance to eating vegetable, and seasonal availability of fruits also leads to low intakes of vitamin A rich foods (Love and Sayed 2001). Similar constraints to low vegetable consumption have been reported by studies conducted among low-income households in the United States of America (Cohen *et al* 1998 and Cox *et al.* 1996 cited by Love and Sayed 2001). These constraints include: poor availability of fruits and vegetables, high costs of fruits and vegetables, lack of proper storage facilities and dislike of vegetable tastes by household members.

Other causes of vitamin A deficiency include: inadequate intake of foods rich in fat and proteins together with foods rich in beta-carotene to enhance absorption of vitamin A in the body (Dunne 1990); lack of resources to produce vitamin A rich foods; shortage of land for agriculture and low incomes to access food from the markets (NICUS undated a).

2.2 Strategies for overcoming vitamin A deficiency

Vitamin A is a fat-soluble micronutrient found in foods as retinol or beta-carotene (FAO 1997). Retinol is found in animal foods such as liver and is absorbed by the human body three to five hours after ingestion (Dunne 1990). Beta-carotene is a provitamin A carotenoid that is more efficiently converted to vitamin A before it is absorbed and utilised by the body six to seven hours after ingestion (Dunne 1990). Traditionally, six micrograms of carotene equal one microgram of retinol (FAO 1997). However, there is limited scientific understanding of how effective carotenoids convert into vitamin A (Children's Nutrition Research Centre (CNRC) 2001).

The most recent bioavailability studies of beta-carotene show that 12 micrograms of carotene yield one microgram of retinol (CNRC 2001). The conversion factor of dietary carotenoids to vitamin A may have been overestimated by previous studies (Smith *et al.* 2001). Conversion of carotenoids into vitamin A in the body is less by half that previously reported (Barr and Thirsk 2001). This may be as low as a quarter of the carotene in carrots and half the carotene in green leafy vegetables (Dunne 1990). Thus, strategies that aim at eliminating vitamin A deficiency should include increasing production and consumption of vitamin A rich foods, combining oil with carotene rich foods to enhance absorption of carotene, as well as providing education about the bioavailability of vitamin A in foods to meet human needs (Ruel and Levin 2000, Smith *et al.* 2001).

People need nutrients in different amounts for a healthy life throughout the life cycle (ACC/SCN 2000). Table 2.2 presents the daily requirements of vitamin A determined by age, sex and physiological status of household members. Pregnant and lactating mothers need more vitamin A for proper growth and development of the foetus and infant since these are the most critical stages of human development (WHO 2000).

Table 2.2 The FAO/WHO recommended daily vitamin A intakes determined by age, sex and physiological status (FAO 2001, FAO and WHO 2002)

Household composition	Vitamin A (RE)
Preschoolers 1-5 years	400
Scholars 6-14 years	600
Women of child-bearing age (15-49 years)	600
Pregnant women	800
Lactating mothers	850
Women 15 years and above	600
Men 15 years and above	700

Note: RE refers to Retinol Equivalent

Children need adequate levels of vitamin A to enhance their growth and support this intense physical activity and rapid mental development (FAO 1997). As people get older, their nutrient requirements decline, as does their level of activity. However, vitamin A requirements remain high to protect the elderly from infections (FAO and WHO 2002). South African children consume only half the recommended vitamin A for their ages (Labadarios *et al.* 2001). Labadarios *et al.* (2001) report that of all South African children, only urban children one to three years old who live in the Western Cape consumed enough vitamin A to meet the recommended intake for their age (Figure 2.1). Sixty-two to 70 percent of children in rural areas and 48 to 62 percent in urban areas consumed less than half the South African recommended dietary allowance for vitamin A (Labadarios *et al.* 2001).

Low consumption of vitamin A among South Africans calls for interventions that will increase security of vitamin A among rural and low-income households of South Africa (Steyn 2000). There are various ways of increasing vitamin A to prevent vitamin A deficiency and to improve children growth and development (FAO and WHO 2002). These include supplementation, food-based approaches such as breastfeeding, food fortification, dietary diversification and introduction of new plants enhanced with vitamin A (Clive 2002, WHO 2000).

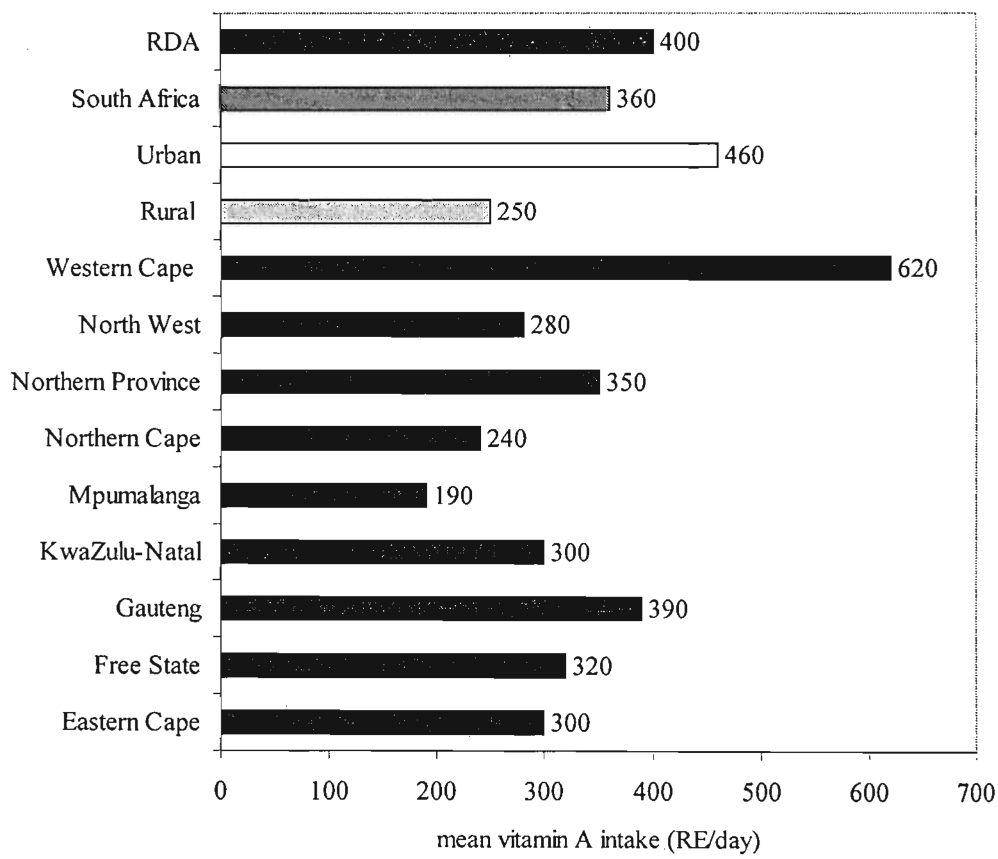

Figure 2.1 The mean vitamin A intake of children aged 1-3 years by province and area of residence as determined by 24 hour recall: South Africa, 1999 (after Steyn and Labadarios 2001, p232)

2.2.1 Supplementation

Supplementation refers to the supply of vitamin A in the form of capsules or supplements and is recommended for people living in areas with high prevalence of vitamin A deficiency and where the severity of the problem is life-threatening (FAO 1992). Supplementation has been successful in many countries (Sifri *et al.* 2002). UNICEF estimated that one million child deaths may have been prevented in 10 countries that provided vitamin A supplements to 70 percent or more of children under-five years between 1998 and 2000 (Sifri *et al.* 2002). Although supplementation has been integrated in national immunisation days or mass campaigns in many African countries and is effective in reducing vitamin A deficiency, it is expensive to carry out (FAO 1992).

Supplementation often does not adequately reach rural populations because many rural areas are inaccessible. Sometimes organisations responsible for supplementation are not able to distribute supplements to a large population due to human resource constraints (Oyunga-Ogubi *et al.* 2002). This approach is not sustainable as it depends on external funding (Benadé 2001, FAO 1992). More sustainable strategies to eliminate vitamin A deficiency include food-based strategies (WHO 2000)

2.2.2 Food-based strategies

Food-based strategies are regarded as long-term interventions for control of micronutrient malnutrition. Food-based strategies aim at increasing household production and consumption of micronutrient rich foods as well as increasing the bioavailability of micronutrients present in the food (Sifri *et al.* 2002). Various approaches to food-based strategies may be adapted. These approaches are discussed below.

The first approach to food-based strategies among infants and children is to encourage mothers to exclusively breastfeed their children for the first four to six months of life, and continue to breastfeed until children are two years old. In order to stimulate breast milk, babies should be breast-fed frequently, but at least five to ten times per day (FAO 1997).

The second approach to food-based approaches is food fortification, that is, adding one or more micronutrient/s to foods that are frequently and widely consumed by the target population (Benadé 2001, Sifri *et al.* 2002). Food fortification is easy to implement in countries where there is adequate distributive infrastructure (Sifri *et al.* 2002). Food fortification reaches the majority of vulnerable people without having much influence on their eating habits (Sifri *et al.* 2002). However, long periods of storage and overcooking vitamin A rich foods can result in the estimated vitamin A loss of 40 percent (Klugman 2003). Thus, fortification alone cannot satisfy the vitamin A needs of vulnerable households (Bagriansky *et al.* 2002)

The third approach is genetic modification of foods. Researchers continue to experiment with improving the vitamin composition of staple foods such as maize, rice and sweet potato through genetic modification (Oyunga-Ogubi *et al.* 2002). The Kenya Agricultural Research Institute has developed varieties of beta-carotene rich sweet potato and the orange-fleshed varieties have been accepted among women farmers (Oyunga-Ogubi *et al.* 2002). However, the success of programmes that promote genetically modified foods is determined by the acceptance of these foods, as little information regarding the safety of genetically modified foods is available to consumers (Sifri *et al.* 2002).

The fourth approach to food-based strategies is dietary diversification, which aims at increasing the variety of foods grown and consumed by household members (NICUS undated a). Food items commonly consumed may lack essential nutrients (Maunder *et al.* 2001). It is therefore important to vary diets to ensure access to essential nutrients at all times (Maunder *et al.* 2001). The variety of foods consumed is determined by availability and access to such foods (Sifri *et al.* 2002). Home gardening plays a crucial role in ensuring production of a variety of vitamin A rich vegetables, particularly for rural populations where supplementation is difficult due to lack of proper roads (Sifri *et al.* 2002, NICUS undated a).

Food based dietary guidelines (FBDGs) have been developed to diversity diets of family members so as to overcome diet-related health problems in South Africa (Maunder *et al.* 2001). The first of the ten food based dietary guidelines is: "Enjoy a variety of foods" which aims at encouraging people to increase variety of foods to include foods from the five food groups, taking into account both the nutritional requirements and family taste preferences. This food based dietary guidelines hopes to influence both the micronutrient and energy intakes, especially of poor households (Maunder *et al.* 2001).

The third of the ten South African food based dietary guidelines is: "Eat plenty of fruits and vegetables every day". High levels of household food insecurity may constrain the objectives of this guidelines "Enjoy a variety of foods" and "Eat fruits and vegetables every day" (Love and Sayed 2001). The participants of the South African food based dietary guidelines study conducted in KwaZulu-Natal and the

Western Cape identified inaffordability and time constraints to purchase and prepare foods as the main constraints to eating vegetables, fruits and foods of animal origins (usually high in vitamin A) (Love and Sayed 2001). For the food based dietary guidelines "Enjoy a variety of foods" and "Eat fruits and vegetables everyday" to be achieved, educational nutrition messages to increase consumption of vegetables and fruits and minimise nutrient loss during preparation must be conveyed to target populations. Where financial constraints are barriers to frequent consumption of vegetables, emphasis for promoting consumption of vegetables and fruits must be put on establishing self-sufficient measures such as vegetable gardens (Maunder *et al.* 2001).

Food-based strategies are long-term nutrition strategies that are successfully implemented if combined with nutrition education (Sifri *et al.* 2002, FAO and ILSI 1997, NICUS undated a). For satisfactory outcomes of food-based strategies employed in the control of vitamin A deficiency, more than one approach must be implemented (FAO 2002). For example, reasonable outcomes are often identified in areas where nutrition education is provided to households, foods that widely consumed by the target population are fortified with vitamin A, supplementation is carried out among the most vulnerable segments of population and home gardening is encouraged among low-income households (FAO 2002).

2.3 The possible contribution of home gardens to South African food and nutrition security

Short-term interventions for control of micronutrient deficiencies are effective in improving the nutritional status of households since they provide specific target groups with vitamin and mineral supplements at certain times (FAO 1997). However, only food-based approaches can prevent micronutrient deficiencies in a sustainable manner for most populations (FAO and ILSI 1997).

In many African countries, efforts to promote home gardening have not received much official recognition due to budgetary constraints (FAO 1997). Thus, FAO and ILSI (1997) urge policy makers and planners to effectively promote food gardens to benefit low-income households. They further argue that gardening activities take time to implement but reap long and lasting benefits, some of which are presented in Table 2.3 below.

Table 2.3 Nutrition and economic benefits of home gardens (FAO and ILSI 1997, Marsh 1998, Nell *et al.* 2000, Schmidt and Vorster 1995)

They are preventive (e.g. micronutrient deficiencies), cost-effective and sustainable.
Culturally acceptable.
The risk of toxicity is at its minimal because the amounts of vitamins and minerals eaten are within normal physiological levels.
They address multiple nutrient deficiencies simultaneously.
They provide 80 percent of vitamin A of RDA.
They are environmentally sound because farmers are cautioned about protecting contents of soil and crops.
Provide higher returns from labour and land than agriculture.
Provide food and income.
Provide independent income for women.
Ensure year-round supplies of vegetable to supplement staple-based diets.
Require low inputs, low cost methods and have low risk.
Provide foods to households during lean periods.

Home gardens contribute a major part to food and nutrition security by ensuring adequate access to supplies of vegetables at all times (Marsh 1998). Home gardening is a cost-effective and sustainable nutrition intervention that provides families with a variety of fresh foods and ensures adequate supplies of quality nutrients to meet household requirements (Marsh 1998, Nell *et al.* 2000). Home gardens can be income generating in that extra income can be obtained from the sale of the produce in cases where the household produces surplus vegetables (Marsh 1998). Further, Schmidt and Vorster (1995) have indicated that production of vegetables at household level improves the consumption of micronutrient rich foods while in turn saves money that was previously used to buy vegetables, to purchase other foodstuffs.

Talukder *et al.* (2001) asserts that home gardening contributes a substantial input towards elimination of micronutrient malnutrition. It is therefore important for countries to share experiences and lessons learned from home garden projects to increase production and consumption of vitamin A rich foods (Talukder *et al.* 2001). A summary of experiences and lessons learned from different home garden projects in developing countries is presented in Table 2.4 to illustrate the potential contribution of food gardens to food and nutrition security of household members.

These experiences and lessons include: first, involvement of community people in the planning of home garden activities to generate people's commitment in the project and to empower them (Cerqueira 1992, Nantel 2002). Community people help in identifying local crops, which they are familiar with. It is easy to build on what people already know while promoting home gardening, although there may be a need to strengthen their knowledge by introducing new ideas (Marsh 1998, FAO and ILSI 1997). An example of a successful home garden project that involved community people from the planning stage is the household food security and nutrition project implemented in (Luapula Valley) Zambia in 1997 where both chronic malnutrition and micronutrient deficiencies were unacceptably high (Callens and Phiri 1998).

Table 2.4 Summary of home garden projects implemented in developing countries to eliminate vitamin A deficiency

Studies	Objective	Implementation methods	Impact of food gardens on food security	Impact of food gardens on nutrition
Household food security and nutrition project in Zambia in Luapula Valley in 1997 (Callens and Phiri 1998)	To increase year-round production of variety of foods for improvement of nutrition.	Community action planning.	Increased production of green leafy vegetables, Increased production of a variety of crops.	Improvement in nutritional status of children.
Building on traditional gardening to improve household food security in Bangladesh in 1990-1993 (Marsh 1998)	To combat vitamin A deficiency and nutrition blindness through home gardening.	Nutrition education, Community involvement.	Increase in the garden sizes, Year-round production of diversity of vegetables.	Reduction in child night blindness, Improved vitamin A status.
A community nutrition project in Viet Nam: Effects on child morbidity (English and Badcock 1998)	To reduce vitamin A deficiency through home gardening beta-carotene-rich fruits and vegetables.	Nutrition education on vitamin A rich vegetables.	Improved nutritional knowledge of mothers, Increased production of fruits and vegetables.	Increased intake of nutrients including vitamin A, Reduction in incidence of infections and severity of illnesses among children, Reduction in stunting prevalence.
A household food production programme to address vitamin A deficiency: A South African experience in 1999 (Faber and Benadé undated)	To increase production and consumption of vitamin A rich vegetables and vitamin A precursor, beta-carotene in KwaZulu-Natal.	Teaching mothers the importance of including vitamin A rich vegetables regularly in family diets.	Increased number of children eating vitamin A rich vegetables, Increased diversity of diets.	Improved vitamin A status.
Home gardening to control vitamin A deficiency in Thailand in 1997 (FAO and ILSI 1997)	To control vitamin A deficiency through production of ivy gourd plant.	Demonstrations, drama, radio spots, posters, public addresses, printed materials.	Increased production of ivy gourd plant.	Increased intake of vitamin A rich foods, Improved vitamin A status.
A creative multi-disciplinary approach towards the development of food in Mangaung, South Africa, 1991 (Nell *et al.* 2000)	To investigate the importance of food gardening for consumption as a tool to improve quality of life.	Multi disciplinary approach, Community involvement.	Year-round availability of variety of vegetables, Improved income levels.	Improved nutritional status of household members.

The aim of this project was to increase year-round production of a wider variety of foods crops that included staple crops, fruits and vegetables so as to increase food consumption, which would provide enough vitamin A, iron, energy and other nutrients. Involvement of people in the project resulted in increased food production and had positive results on the nutritional status of children (Callens and Phiri 1998).

Second, an integration of nutrition education in home garden projects is fundamental in ensuring a link between the availability of nutritious food crops grown in home gardens and their consumption, and consumption and bioavailability of nutrients or absorption of these nutrients by the body (Marsh 1998). To ensure that food gardens translate into nutritional well-being for every household member, creating awareness of nutritive value of foods and their utilisation in family's diet is essential (FAO 1997).

Successful home garden projects combine strategies that address both increased production of vitamin A rich vegetables and increased consumption and are able to address the needs of special groups such as young children and women of child bearing age (FAO and ILSI 1997). Through nutrition education, farmers can expand their knowledge of crop diversification, choice of species, cropping patterns, diversity and cultivation of local varieties to enhance nutritional status of household members (FAO 1997).

Farmers in Luapula Valley in Zambia became aware of nutritional problems and understood nutritional requirements through nutrition education (Callens and Phiri 1998). Hence the farmers prioritised production and preparation of green leafy vegetables to improve the nutritional status of their children (Callens and Phiri 1998). In Bangladesh, Hellen Keller International (Non-Governmental Organisation) implemented a home gardening project that combined nutrition education with vegetable production to eliminate vitamin A deficiency (Marsh 1998). A pilot project was conducted to test whether production of vitamin A rich vegetables using low-cost methods, when combined with nutrition education, may improve nutritional status of people. For sustainability of the project, community people were involved in its design. Women in participating villages were trained how to grow vegetable seeds into seedlings using a low-cost, low risk methods and also shown appropriate processing and cooking methods (Marsh 1998).

After two years of operation, the project reported an increase in the size of home gardens from 62m^2 to 137m^2 and the average of three varieties of vegetables increased to seventeen (Marsh 1998). Monthly income increased and women in the target group were able to make decisions over income obtained from surplus sales (Marsh 1998). In Bangladesh, vegetable consumption increased by 30 percent, while 80 percent of vegetables consumed by households came from home gardens (FAO 1997). As consumption of vegetables increased and the income from surplus sales was spent on food, the nutritional status of children improved significantly (FAO 1997). Night blindness among children in Bangladesh decreased from two to one percent in participating villages although prevalence beyond one percent is still considered a public health problem (Marsh 1998).

A similar project was implemented in Viet Nam in four communities. The aim of the project was to reduce vitamin A deficiency through home gardening, beta-carotene rich fruits and vegetables (English and Badcock 1998). Nutrition education was provided to mothers in participating communities resulting in many women showing a better understanding of which foods were rich in vitamin A. Monitoring showed significant improvements in the nutritional status of children in target communities compared to the baseline data (Ruel and Levin 2000).

Gardening projects aimed at determining the potential of home gardens in improving vitamin A status of individuals was implemented in rural KwaZulu-Natal in South Africa (Faber *et al.* 2002). Prior to the start of the project, baseline data showed that 50 percent of children two to five years old had vitamin A below 20μg/d*l* (marginal vitamin A status) and they depended on staple foods such as maize porridge, bread and rice (Faber *et al.* 2002). Children one to five years old in KwaZulu-Natal consumed only 35 percent of vitamin A of the RDA for this age group (Faber *et al.* 2002). The programme incorporated community-based growth monitoring activities.

After 20 months of project implementation, increases in production and consumption of vitamin A rich vegetables and vitamin A precursors considerably increased, resulting in an increased number of children consuming vitamin A rich vegetables (Faber *et al.* 2002). There was also an increase in the diversity of family diets that led to a significant improvement in vitamin A status of household members (Faber and Benadé undated). The programme was successful due to people's involvement in the project and the creation of awareness of vitamin A rich vegetables such as spinach, carrots and pumpkin among community people, particularly mothers (FAO 2002). Ruel and Levin (2000) have noted that home gardens play a significant role in reducing vitamin A deficiency in developing countries when nutrition education is included.

Third, it is important for people to understand their nutritional needs and if messages are effectively communicated to them, their eating practices are likely to change for the better. Increases in consumption of vitamin A rich foods may result from a variety of communication channels such as radio, television and print media. It is important to choose communication strategies preferred by target population (FAO and ILSI 1997).

Home garden projects in Thailand that aimed at controlling vitamin A deficiency intensively communicated production of ivy gourd plant at a time to farmers through demonstrations, drama and village active programmes (FAO and ILSI 1997). Other channels included radio, public addresses, posters, videos and printed materials. The strategy was cost-effective and significantly increased production and consumption of vitamin A rich foods resulting in improvement in vitamin A status of the population (FAO and ILSI 1997).

Fourth, promoting both the nutritional and economic benefits of home gardens is crucial to attain increases in the production and consumption of vitamin A rich foods. Home garden projects that take into account the primary objective of household gardening have been successful, that is, whether households wish to produce for consumption only or for consumption and income generation (FAO and ILSI 1997). Gardeners become interested in gardening activities once they understand both the economic and nutritional benefits of home gardening (FAO and ILSI 1997). Schmidt and Vorster (1995) have noted that participants of a communal garden in Bophuthatswana (a former South African homeland) benefited economically rather than nutritionally from the project by saving money used to buy vegetables prior to the start of the project and used it to buy other foodstuffs such as oil and fat.

Fifth, understanding the different roles of family members in home gardens helps in the planning of targeted in garden management education (FAO 1997). Women play the major role in household gardens, while men perform heavy tasks such as clearing land and digging. Children fetch water and water plants, while the elderly advise on production and consumption of indigenous vegetables. Thus, where training is provided, every household member who takes part in the garden should be included (FAO 1997).

Sixth, integrating other sectors into home garden projects speeds up the process of project implementation (FAO and ILSI 1997). The role of government is to provide extension services, access to land and other resources where there are needs (FAO 1997). An example of an integrated project is the partnership between Mangaung communities, the University of Orange Free State, Department of Health of Orange Free State Province and Kellogg Foundation of the United States that worked together to increase availability of micronutrient-rich vegetables in the Free State (Nell *et al.* 2000).

Ruel and Levin (2000) have shown that home gardens improve household food supplies, dietary quality and increase availability of vitamin A rich vegetables throughout the year. However, production of vegetables in home gardens is constrained by environmental factors such as poor soils and climatic conditions and socio-economic factors such as shortage of labour and poor access to farm inputs discussed below.

2.4 Factors that contribute to low production of vegetables in home gardens

Many households in African countries encounter various problems in home gardens, which result in low production of vegetables (Table 2.5) (FAO 1995a, Loehr *et al.* 1998). Some factors that limit production of vegetables in home gardens include both environmental and socio-economic factors (National Botanic Institute (NBI) 1999).

Table 2.5 Factors that contribute to low production of vegetables in home gardens (after FAO 1995a)

Stage of food system/ problem	Typical problems in food system/ causes of problems
Home garden land	Shortage of land, Insecure tenure, Infertile land.
Clearing the garden	Limited labour, Use of hand tools limit amount of land to be cleared, Late land preparation, Insufficient time.
Planting the garden	Limited variety of crops, Poor seed distribution, Limited inputs, Limited extension advice, Women farmers not consulted by extension services, Limited family labour, Water scarcity.
Harvesting the garden	Stealing of crops, Labour shortage, Late pests damage, Animal interference.
The productivity of home garden has not reached its potential	Soil improvement methods not fully used, Cropping system not suitable, Individual plant productivity not good, Soil infertility.
Home gardens do not meet daily food needs	Households not aware of appropriate crops, Households do not have access to enough planting materials.

2.4.1 Environmental constraints to home gardening

Gardening becomes difficult in areas of low rainfall (FAO 1995a). Dry areas are more vulnerable to soil erosion than wet areas because in dry areas, the soil becomes loose and is easily washed away by rain (Bos 1994). Prevailing climatic conditions determine the yield and quality of plants (Young and Allemann 2002). In some areas of South Africa, there is scarcity of water, while in other areas, too much water prohibits the production of some crops (NBI 1999, Marsh 1998). In flooding areas, recommended gardening techniques include raised beds, drainage canals, production of water loving plants such as leafy vegetables, plastic coverings, and introduction of storage water tanks (Marsh 1998, FAO 1995a). Annual crops may be grown in heaps of soil to drain off surplus water. Mulching in wet seasons keeps the soil too wet and so is avoided in wet areas, but encouraged in areas of low rainfall (FAO 1995a).

In dry areas, it is important to employ water conserving horticultural practices, production of drought resistant crops such as cassava and egg plant, short term vegetable food crops or seasonal gardening, and use of household water waste for irrigation (Marsh 1998, FAO 1995a). When planting, it is important to make a basin-like or sunken area around the crop to prevent water from running off (FAO 1995a). Other strategies for dry vegetable gardening include growing some vegetables under the shade and removing weeds because they compete for moisture with vegetables (FAO 1995a). In cases where there is total scarcity of water and gardening competes with household water needs, it may be advisable to grow only a few perennial crops (Marsh 1998). Often households produce vegetables in rainy seasons when water is in abundance and crops are rain-fed (Bos 1994).

In dry seasons, households in many rural areas have to fetch water for both household use and vegetable production. This is usually the responsibility of women and children (FAO 1997). Women have many responsibilities such as taking care of children, fetching fuel and sometimes they are involved in off-farm jobs (FAO 1997). Therefore, fetching water for gardening purposes is often not households' priority and this has additional negative impacts on vegetable production (Bos 1994).

Some gardeners are inhibited by poor soil fertility or lack of cultivable soil (Marsh 1998). Often gardeners acquire knowledge from schools, agriculture extension agents and other farmers (Bos 1994). However, in Zambia, extension workers do not provide much information to gardeners and in some cases, where meetings are held for gardeners, more men than women attend and few women ask questions (Bos 1994). In Lesotho, many households in the rural areas have home gardens, but do not produce vegetables in winter season when it is cold because gardeners do not have the knowledge on winter gardening techniques (Food and Nutrition Coordinating Office (FNCO) *et al.* 2001). While it is important to disseminate information on vegetable production to households, the cost of inputs must be taken into account (Marsh 1998).

Gardens located on sloping land are vulnerable to the washing away of fertile topsoil through soil erosion, leaving less productive soil that results in low production of vegetables (FAO 1995a). This could be overcome by keeping the soil covered. Appropriate measures of preventing soil erosion include clearing only an area that is to be planted if the garden is cultivated for the first time. For gardens that have been planted before, soil has to be covered with plants or mulch (FAO 1995a). Development of low-cost methods of soil fertility improvement such as building up the soil with compost (leaves and animal manure) improves the structure of both heavy and sandy soil (Marsh 1998). This will enable households to grow a wide range of healthy food crops, which are less likely to be affected by insects and diseases. Multi-layer cropping and mixing crops that mature at different times help protects soil and improves its nutrients (FAO 1995a).

Weeds are problematic in vegetable gardens because they compete with vegetables for nutrients, water, sunlight and space, causing vegetables to grow poorly and die prematurely (Young and Allemann 2002). Grasses can interfere with plants but prevent soil erosion. Weeds can be dug out with a knife or hoe and can be used as mulch if they do not contain seeds as seeds will germinate and generate more weeds. Mulching helps cover the soil to prevent weeds from getting sunlight and growing. Other ways of preventing weeds include planting crops that shade the soil surface and mix crops (FAO 1995a).

Pests, insects and diseases impede vegetable production (FAO 1995a). Insects are often seasonal, occurring more in rainy seasons. Pests and diseases are less likely to attack plants that are well looked after (Drescher 2001). To prevent pests and disease problems in food gardens, gardeners should choose crops that are suited to local conditions, rotate crops to prevent build up of diseases in the soil caused by continual planting of the same crop, and remove diseased plants before they infect others (Young and Allemann 2002).

Domestic animals such as chickens, pigs, sheep, goats and cattle destroy vegetables in food gardens (Marsh 1998), especially in dry seasons when other food sources for animals are limited (FAO 1995a). Sometimes low-income households cannot afford fences for their gardens in areas where local fencing materials such as fence shrubs are not readily available (Marsh 1998, NBI 1999, FAO 1995a). While it is important for families to keep livestock, it also depends on their preference for either plants or livestock unless livestock are housed (Marsh 1998). Another problem faced by households is crop theft, which seems to increase when the garden is situated away from the homestead. This could be overcome better by locating a garden closer to a homestead (Bos 1994).

2.4.2 Socio-economic constraints to home gardening

Socio-economic constraints to vegetable production include poor access to farm inputs, shortage of labour, insufficient time, inadequate knowledge and skills in vegetable production management (Marsh 1998). Households need high quality seed to produce high yields (Young and Allemann 2002). Seed is more accessible in urban areas than rural areas (Bos 1994). This implies that gardeners in rural areas require time, money and access to transport in order to obtain seeds or use seeds preserved from previous seasons although it is often less productive than purchased seed supplies (Bos 1994).

Rural populations' access to farm inputs such as fertilisers and pesticides is constrained by poverty and remoteness of areas. When fertilisers are subsidised, poor farmers may easily access them (Bos 1994). However, for the health of consumers and safety of the environment, use of chemicals in home gardens is not recommended (Drescher 2001), while the use of organic techniques reduces dependence on these inputs (Frankenberger *et al.* 1989).

Shortage of labour often results in low vegetable production (Bos 1994). In developing countries, women, men and children contribute significantly to gardening activities. In rural areas, women play a major role, especially in maintenance of the garden while men contribute to heavy jobs such as clearing the land, while children collect water for the plants (FAO 1997). In urban areas of Zambia, men take the lead in gardening activities because their primary objective is to produce for income generation (Bos 1994). However, in rural areas, women focus their labour on production of field crops rather than home gardening while in urban areas both men and women focus on income-generating activities. In both cases, the result is low production due to shortages of labour. Female-headed households are more vulnerable to low production of vegetables because of shortage of men's labour to undertake some of the heavier tasks of production (Bos 1994).

There are many factors that influence the amount of time that is spent on gardening activities (Bos 1994). These include: the primary function of the garden, types of crops grown and garden size. If more exotic vegetables than traditional vegetables are grown, additional time will be required for watering. Traditional vegetables usually require little water because they are often more suited to local climatic conditions than exotic vegetables (FAO 1995a). Unlike wet season gardening, dry season gardening and big gardens require more labour and therefore more time (Bos 1994).

2.5 How organic production increase availability of vegetables by overcoming constraints to home gardening

While it is essential to produce enough food to meet household consumption requirements, the environment must be sustained in order to support future production so that future generations can also produce enough food on the same land (FAO 1997). Organic farming methods are often considered as natural because crops are produced within the natural processes that protect the environment (Appropriate Technology Transfer for Rural Areas (ATTRA) 2002). Organic gardening refers to production of food crops that excludes the use of inorganic chemicals in the form of fertilisers and pesticides (Brummond 1996). Organic gardening relies on natural pest and disease control measures (White 2001) that promote build up of beneficial insects such as lacewings and big-eyed bugs that break pest cycles (National Selection Foods (NSF) 2001). Beneficial insects eat eggs of pests and prevent pests from damaging crops by providing them with an alternative food source. Thus, a border of flowering plants such as carrots and radish is established around the garden to attract beneficial insects (NSF 2001).

Organic gardening emphasises biodiversity, which refers to the mix of species on the same piece of land to support beneficial organisms that help in pollination and disease control (ATTRA 2002). Biodiversity also increases aroma to repel some insects and provides nutrients such as nitrogen to the soil, which improves crop production. Practices that increase biodiversity include companion planting, crop rotation and successive planting (ATTRA 2002).

Companion planting refers to the mixed production of synergistic crops in the same rows or production of different crops between two rows of crops (Lindgren *et al.* 1990). Synergistic crops include beans-potatoes, peas-carrots, peas-turnips, cabbage-beets, spinach-cauliflower, spinach-eggplant, corn-cucumber and corn-beans (Brummond 1996) or maize-beans, beans-squash or beans-pumpkins (ATTRA 2002). Crop diversification protects crops from drought, floods, pests and diseases (FAO 1997). Growing cultivars that mature earlier is best because insects and diseases have less time to damage the vegetables. In addition, crops that mature earlier can be mixed with those that mature later (FAO 1995a). Root crops can be interplanted with vegetables and staple crops such as maize (FAO 1995a).

Crop rotation, which also increases biodiversity, refers to the production of different crops on the same land that are seasonal alternated (Boyhan *et al.* 1999, Petzoldt 2002). Crop rotation reduces the build up of diseases in the soil and breaks pest cycles by growing an unrelated crop that is preferred by different pests (Klonksky *et al.* 2001). Figure 2.2 demonstrates rotational or successive cropping of vegetables.

Plants of the same family are normally attacked by the same pathogens and therefore must not be planted in rotation or succession to avoid the build up of diseases (Lindgren *et al.* 1990, Boyhan *et al.* 1999). Organic gardeners rotate unrelated vegetables such as root crops after potato or sweet corn, sweet corn after cabbage, peas after tomatoes and tomatoes after beans (Brummond 1996).

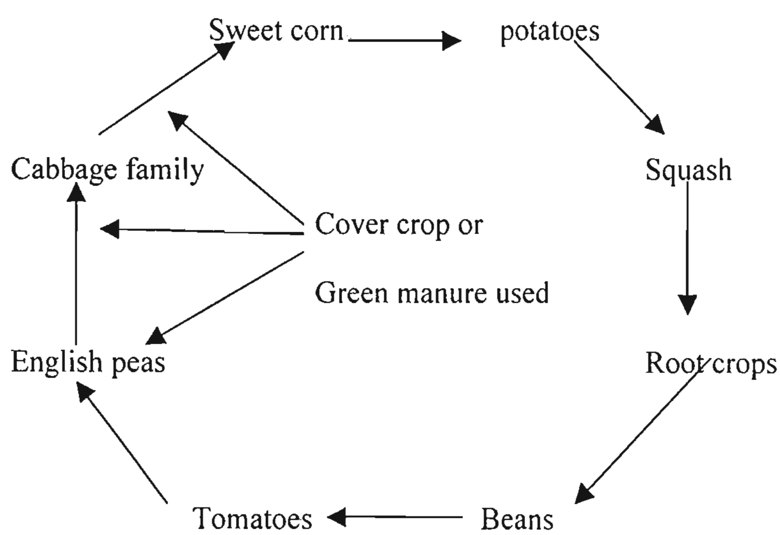

Figure 2.2 Vegetable crop rotation (after ATTRA 2002)

In situations where vegetable gardens are small, crop rotation becomes difficult to carry out, although it is important to rotate crops within the space available (Schrock 1998). Successive cropping is more suitable for home gardening than crop rotation. Successive cropping is the production of more than one type of vegetable in the same space during the year (Mississippi State University Coordinated Access to Research and Extension System (MSU Cares) 2002). After harvesting one crop, an unrelated crop to the one just harvested is grown and if planting is done at two-week intervals, a continuous supply of fresh vegetables will be ensured (MSU Cares 2002).

Composting and manuring contribute to biodiversity by ensuring healthy soil that produces healthy plants (White 2001). Compost is a soil-like material that is made from plant materials and constructed to improve soil fertility (Boyhan *et al.* 1999). Green manuring refers to the process of growing plants on the land and turning them into the soil to increase organic matter, soil nutrients and reduce disease problems (Boyhan *et al.* 1999).

Regular application of compost and manure ensures productive soils throughout the lifespan of plants (Guanzon and Holmer 2002). Compost and manure improve physical, biological and chemical structure of the soil although the nutrients are not readily available and are less concentrated. Such nutrients include nitrogen, phosphorus and potassium. Nitrogen facilitates plant growth, green colour and resistance to disease and is found in animal manure. Phosphorus assists in early maturity of seed and fruit, formation of roots and resistance to drought and is high in chicken manure. Potassium moves nutrients around the plant and helps roots and stems to grow strong. Sources of potassium include animal manure, ash and maize-cobs (Guanzon and Holmer 2002).

Animal manure is also a good source of nutrients for soil. Fresh animal manure should not be used in the garden because it burns plants (FAO 2001). Compost and manure are added to the soil to increase the amount of natural material in the soil, while they also improve the water-holding capacity and physical structure of the soil (Lindgren *et al.* 1990). It is important to grow insect repellent crops such as onions, leeks and garlic between plants to prevent diseases (FAO 2001). Another method of controlling insects and diseases in vegetable gardens is through sanitation, which is removal of diseased plants and old plant residue from the garden to prevent diseases from spreading to healthy plants (Lindgren *et al.* 1990).

Weed control is important in organic gardens because weeds compete with vegetables for nutrients, soil moisture, sunlight and space and weeds can sometimes attract insects (FAO 2001). Cover crops such as pumpkin, cowpea and sweet potato and mulching prevent the soil surface from receiving sunlight to allow weed growth (FAO 1995a). Cover crops increase soil structure and retain soil moisture (Klonksky *et al.* 2001, FAO 2001). Mulching is the covering of the soil surface with organic materials such as leaves, grass and sawdust laid between plants to prevent sunlight reaching soil surface (Ells *et al.* 2001).

Mulching retains soil moisture and thereby reduces the frequency of watering, regulates soil temperatures that encourage root growth and conserves soil nutrients and structure (Gilbert and Hadfield 1987). In addition, mulching prevents water from splashing on plants, keeps them clean and reduces chances of diseases, while in turn it facilitates better growth of plants, better yields and extends the growing and harvesting periods of plants by preventing the soil from rapid warming and drying out (Boyhan *et al.* 1999). It is important to use natural mulches such as straws, leaves and newspaper that can be forked in when they have decayed in order to improve soil structure (Gilbert and Hadfield 1987, Lindgren *et al.* 1990).

Organic gardening differs from conventional gardening in cultural practices and pest and disease control measures (White 2001). Conventional gardening has been successful in many cases in increasing vegetable supplies and bringing positive changes to children's nutritional status (Addison 2002). However, conventional gardening requires inputs such as inorganic fertilisers and pesticides that are not easily accessible to many households. Organic gardeners prefer to use natural and organic materials and methods that are approved for organic production (Lindgren *et al.* 1990). If gardeners call their produce "organic", certification is necessary for marketing (Lindgren *et al.* 1990). However, home gardeners who produce organically do not need certification if not marketed as organic (Brummond 1996).

2.6 Vitamin A rich vegetables suitable for home gardens

A range of vegetables can be grown in home gardens throughout the year to provide a constant supply of vitamin A and other nutrients important for survival of household members (Blum *et al.* 1997). Each vegetable has more than one nutrient and each nutrient has a specific function in the body as is indicated in Table 2.6 (FAO 1997). The vitamin A content of the food is identified by dark green, red and yellow colours of vegetables.

Table 2.7 gives examples of vegetables that are rich in vitamin A and that grow well in home gardens, and their vitamin A content. Dark green vegetables such as swiss chard, beet leaves, turnip greens, peppers and tomatoes, root vegetables like carrots are good sources of vitamin A, containing more than 500μg of vitamin A per 100g of edible potion (Blum *et al.* 1997, FAO 1997). Dark green vegetables contain more vitamin A than lighter green vegetables, although lighter vegetables may also contribute significant amounts of vitamin A if sufficient quantities are eaten (FAO 2001).

Table 2.6 The functions of important nutrients found in vegetables (FAO 1995b)

Nutrients	Functions	Vegetables sources
Iron	Makes blood strong, Prevents anaemia.	Beet leaves, spinach, swiss chard, carrots.
Calcium	Builds healthy bones and teeth.	Beet leaves, broccoli, carrots.
Protein	Builds the body and impair tissues.	Green leafy vegetables.
Vitamin A	Maintains good eyesight, Enhances immune system,	Beet leaves, broccoli, cabbage, carrots, leeks, pepper,
	Facilitates growth and development of the body.	Pepper, spinach, tomato, turnip and radish tops.
Vitamin B	Increases concentration, Enhances immune system.	Onions, garlic, leeks, pepper, turnips.
Vitamin C	Fights against infections, Helps the body convert carbohydrates into energy and heat, Keeps body tissues strong, Helps the body utilise iron, Helps wounds to heal, Fight infections.	Broccoli, cabbage, leeks, lettuce, onions, pepper, tomato, turnips, carrots.
Dietary fibre	Prevent constipation, Helps regulate bowel motions, Lower blood cholesterol, Prevents heart disease.	Green leafy vegetables.

Both the tops and roots of some vegetables such as radish, beets and turnips are eaten. However, their leaves are more nutritious in terms of micronutrients than the main crops, but are often eaten in smaller quantities than the roots, especially in Africa (Ruel and Levin 2000 and World Bank 1998). Half a cup of cooked turnip greens for instance would provide half the daily vitamin A needs of a young child (FAO 1995b). Although the protein that is found in vegetables may not be important in developed countries, it plays a vital role in developing countries where households often live on staple-based diets (Siemonsma and Piluek 1993).

Table 2.7 Vitamin A content of home garden vegetables (after Gouws and Langenhoven 1986, Blum *et al.* 1997 and FAO 2001)

Vitamin A rich vegetables	RE µg/100g of edible potion	Rating value[1]
Green leafy vegetables		**1-4**
Beet leaves	1179	4
Broccoli	135	3
Chinese cabbage	12	1
Lettuce	162	3
Pepper leaves	22-501	2-4
Radish tops	542	4
Swiss chard	969	4
Turnip greens	1060	4
Root and fruit vegetables		**0-4**
Beets	5.4	1
Red pepper	524	4
Carrots	1250	4
Radish	0	0
Green pepper	60	1
Tomato	237	3
Turnips	0	0

Note: RE refers to Retinol Equivalent

Green leafy vegetables can be harvested three to four times before replanting, and a variety of leafy vegetables such as spinach and swiss chard can be harvested three to

[1] Rating values range from 0 to 4. Zero means no vitamin A present in the vegetable, 1 indicates a trace of 1 to 10RE/199g, 2 indicates small amounts of 11 to 100RE/100g, 3 indicates medium amounts of 101-500RE/100g and 4 shows large amounts of 500RE/100g (Blum *et al.* 1997).

eight weeks after planting (FAO 2001). Spinach and swiss chard are good sources of vitamins and minerals.

They also contain protein, carbohydrates, magnesium, calcium and iron (van Antwerpen 1993, Uys 1997). Spinach grows well in temperatures of 15-20°C and can grow in cold seasons (Siemonsma and Piluek 1993). Because swiss chard is not sensitive to heat and frost, it can be planted all year in South Africa, except in May and June in cold areas as severe cold may damage seedlings (Uys 1997). Swiss chard does not need much attention and it bears leaves all year round no matter how often the leaves are picked up (Siemonsma and Piluek 1993).

Broccoli is high in vitamin A and C, calcium, potassium and phosphorus and contains small amounts of iron, thiamine, riboflavin, sodium and niacin (Uys 1997). Broccoli grows well in rich soil but can be stunted in poor soils (Gilbert and Hadfield 1987). It is a cool weather crop that enjoys moist climates (Gilbert and Hadfield 1987). Seeds are sown in trays and transplanted four to five weeks after planting. Broccoli can be harvested continuously from eight to ten weeks after transplanting (Uys 1997).

Lettuce is a highly perishable crop. Headed lettuces with low chlorophyll contents have lower micronutrients than leafy lettuce varieties (Siemonsma and Piluek 1993). Dark green types have more beta-carotene, iron and vitamin C than lighter green varieties. Lettuce is a cool weather crop that needs optimum temperatures of 15 to 25°C, although there are cultivars such as '*Grand Rapids*' (loose-leaf lettuce) and (butter lettuce) that are tolerant to heat (Uys 1997). Lettuce is sown directly from seed and thinned out 14 days after sowing (Uys 1997). It can be grown directly from seed although lettuce grown from seedlings yields larger heads (Gilbert and Hadfield 1987). Lettuce can be harvested two to three months after sowing.

Root vegetables such as beets and carrots are widely grown in home gardens of South Africa, growing well throughout the year (Nell *et al.* 2000). Beets are rich in carbohydrates and fibre and have low amounts of vitamins and minerals (van Antwerpen 1993). However, beet leaves contain high concentrations of vitamins and minerals (Siemonsma and Piluek 1993). The nutritive value of beet leaves is similar to that of swiss chard. Beet leaves can be harvested 45 days after planting while the roots can be harvested two to four months after planting depending on the size of the roots preferred (Siemonsma and Piluek 1993). Beets grow well in temperatures of zero to four °C and are resistant to cold, although it does not tolerate severe freezing. In places where temperatures are severely low in winter, beets are grown in spring, summer and autumn (Wester and Kehr 2002). Although beets are cool weather crops, they can tolerate high temperatures provided there is enough soil moisture (Gilbert and Hadfield 1987).

Carrots are good sources of beta-carotene, vitamin C, calcium and iron (FAO 1995b). Carrots grow well in any type of soil as long as it is moist, fertile, loose and free from stones. Carrots can be sown directly where they are to mature, and are thinned 14 days after planting (van Antwerpen 1993). Carrots are not tolerant to drought and very low temperatures (Bennett 2002). They grow well in winter, as long as temperatures do not fall to freezing point. If it is very cold, the carrot garden must be covered with thick layers of leaves or straw to prevent the ground from freezing (MSU Cares 2002). Maximum yield of carrots is obtained at planting density of 200 plants per square metre and for bigger carrots, the density may be reduced to 100 plants per square metre (Siemonsma and Piluek 1993). Carrots are harvested two to four months after planting when the sugar content is highest and they are at their sweetest taste. If harvested too early, they do not have enough sugar and if they are harvested too late, they lose their sweetness. The brighter the colour of the carrot, the better the taste (MSU Cares 2002). Carrots and beets can be planted at the three-week interval to ensure continuous supply (Uys 1997).

Peppers are also good sources of vitamin A and C (Uys 1997). Of the provitamin A carotenoids present in peppers, beta-carotene amounts to 95 percent in mature green peppers and 93 percent in mature red peppers (Howard *et al.* 1994). The long green and red chilli pepper cultivars have the highest provitamin content compared to other peppers, irrespective of maturity stage. At maturity, red peppers have 225 percent more beta-carotene than green peppers. The beta-carotene content of peppers decreases during processing, although mature green cultivars are less affected by heat than mature red cultivars. Mature red pepper cultivars have 501.9μg RE/100g while mature green peppers have 22-111.14μg RE/100g (Howard *et al.* 1994).

The content of beta-carotene in peppers differs between cultivars and the environmental conditions in which they are grown (Siemonsma and Piluek 1993). Peppers require full sun and grow best in rich soils (Williams *et al.* 1991). Picking is done when coloured and green peppers are firm and have reached maximum size. (Williams *et al.* 1991). Frequency of picking increases the yield of peppers (MSU Cares 2002).

Tomato is an edible fruit that contains vitamins A, B and C, magnesium, calcium and iron (Uys 1997). It is a warm weather crop that grows well in temperatures of 21 to 24°C (van Antwerpen 1993). In cool seasons, tomatoes can be harvested 90 to 110 days after planting, while in warm seasons harvesting can be done 60 to 90 days after planting (Siemonsma and Piluek 1993). Growing tomatoes from seedlings is more advantageous over direct seeding because seedlings require a small quantity of seeds and it is easier to identify pests and diseases at an early stage. Tomato seedlings are transplanted three to four weeks after sowing when they are four centimetres high (Siemonsma and Piluek 1993, Uys 1997).

Some vegetables such as onions, leeks and garlic are important in home gardens because they repel pests (Opeña and Kyomo 1990). They are used in several dishes such as stews and soups as flavourings and to stimulate appetite (Opeña and Kyomo 1990). Onions, leeks and garlic contain vitamins B and C. Leeks contain small amounts of vitamin A, protein, fat and calcium and they provide 128kJ per 100g (Siemonsma and Piluek 1993). Leeks grow best in temperatures of 20°C to 25°C and are more tolerant to cold weather than onions. Leeks are sown between January and February and also between August and September and are harvested throughout the year after sowing (Siemonsma and Piluek 1993).

Onions are a good source of calcium, phosphorus and potassium. They strengthen the immune system and lower cholesterol levels (Uys 1997). Onions do well in temperatures below 20°C and maximum yield of onion is obtained at planting density of 80 plants per square metre (Siemonsma and Piluek 1993). There are different varieties of onion that can be planted and harvested at different times and harvesting is done six months after sowing (Uys 1997). Garlic contains allicillin oil, which has antibacterial properties. It stimulates blood circulation and digestion and reduces fever attacks. Maximum yield of garlic is obtained at planting density of 50 to 70 plants per square metre (Siemonsma and Piluek 1993).

In order to a ensure year-round production of a variety of vegetables that are rich in vitamin A, gardeners must understand the interrelationship of factors influencing their gardens (FAO 2001). For example, the type of crops that grow well in the area, appropriate planting times, growing periods and the length of harvesting periods of the different crops have to be taken into account (MSU Cares 2002). High and low temperatures can damage the seedlings and therefore plants should be selected based on their climatic requirements (Siemonsma and Piluek 1993). In addition, gardeners must know which types of crops to grow and when, where and in which mixtures to grow them (FAO 1995a). Gardeners must be familiar with, and take advantage of, living fences, multiple cropping, multi-layer cropping and intensive vegetable gardening techniques (FAO 2001).

2.7 Summary

Vitamin A deficiency is widespread, both globally and in developing countries. The South African National Food Consumption Survey (1999) indicated that one in three children aged 6 to 71 months had marginal vitamin A status, indicating low intake of vitamin A rich foods. Causes of vitamin A deficiency include: failure to exclusively breastfeed children for four to six months of their first life as breast milk has enough vitamin A for infants, dependence on staple-based diets, poor intake of vitamin A rich foods and lack of dietary diversity.

Food items commonly consumed among children in South Africa include maize, sugar, tea, whole milk, brown bread and margarine, indicating low intakes of micronutrient rich foods. In South Africa, margarine is fortified with vitamin A and could be the source of vitamin A. However, margarine is consumed in small amounts. Subsistence agriculture plays a role in the supply of foods to low-income South African households, but does not ensure adequate supply of vitamin A rich vegetables. Consumption of fruits is low among low-income households in South Africa.

Various measures for control of vitamin A deficiency exist. These measures include: supplementation, food fortification, genetic modification and dietary diversification. Food-based dietary guidelines have been developed to increase variety of foods eaten including vegetables and fruits on a daily basis. Food-based approaches are sustainable when nutrition education is included and home gardens are easy and cheap to implement, especially in rural areas where supplementation is not easy to carry out.

Home gardens can provide households with year-round supply of vitamin A rich vegetables, which also supplement staple diets. Income is generated where surplus is available and households save money, which was previously used to buy vegetables for other foods such as oils and fats. Experiences from Zambia, Bangladesh, Viet Nam and Thailand, and South African provinces such as KwaZulu Natal and Free State indicate the potential of home gardens in increasing consumption of vitamin A rich vegetables and, in turn, resulting in improved vitamin A status of household members.

However, poor access to inputs such as high quality vegetable seed, pesticides, fencing materials and fertilisers inhibit vegetable production in household gardens. Many constraints can be overcome by the use of organic methods, which reduce dependence on purchased inputs. Other factors that constrain production of vegetables in home gardens are shortages of labour, insufficient time and inadequate skills and knowledge of vegetable production management.

The literature reviewed in this chapter indicates the potential for production of vitamin A rich vegetables to improve the consumption of a variety of vitamin A rich foods by low-income households and, in turn improve household vitamin A status. Studies reviewed suggest that organic gardening techniques could be incorporated into the development of a household organic garden unit to encourage production of vitamin A rich vegetables throughout the year.

CHAPTER 3

DESIGN OF GARDEN UNIT

The garden unit adapted for this study was originally promoted in Europe between the late 1970s and early 1980s (Addison 2002). This garden attempts to intensify production of vegetables in a small space as opposed to traditional gardens that typically have long, single rows of widely spaced vegetables (Addison 2002, Guanzon and Holmer 2002). The development of the garden unit took into account households with small plots, low incomes and insufficient time to carry out extensive gardening. This chapter presents the design of the garden unit.

3.1 The characteristics of the garden unit

One garden unit was intended to meet the daily vegetable consumption needs of one person. Thus, the number of household members above one year old (because young children consume small portions of vegetables) determines the number of garden units required for each household (Addison 2002). The garden unit was designed following the steps listed in Table 3.1 provided by Bartholomew (1992) and Addison (2002). The garden unit is a raised bed that is subdivided into 16 equal squares (Appendix A and B). Each square should contain a different crop with small plants in the front, bigger ones in the middle and tall ones at the back of the plot to allow all plants to have exposure to sunlight for at least six hours a day (Addison 2002).

Table 3.1 Steps in the design of a garden unit (Bartholomew 1992, Addison 2002)

1.	An area of 122 cm x 122 cm on the ground is measured.
2.	The garden is built in raised beds of 15cm high and edged with bricks or stones to avoid soil erosion. Where there is no place, 2 planks of 122cm long x 3cm wide x 10cm deep and 2 other planks of 116cm long x 3cm wide x 10cm deep are cut. The ends of 122cm planks to 116cm planks are connected to make a garden. Then the garden is filled with soil.
3.	The garden is divided into 16 squares of 30cm with string.
4.	Each square is planted with a different crop.

The garden unit integrates cost-effective methods that poor households may afford. Garden resources employed are often readily available at homes (Appendix C). A spade, wheelbarrow, fork and rake are useful when making compost, and for initial digging of a garden. When the garden bed is built, the watering can and a dibber (used to make seed and seedling holes) are used to manage the garden (Shaw 1998). Shrub branches and produce packaging are recommended to fence the garden unit to prevent animal interference.

3.2 Selection of vegetables for the garden unit

Thirteen vegetables (including beets, broccoli, carrots, chinese cabbage, garlic, leek, lettuce, onion, peppers, radish, swiss chard, tomato and turnips) were selected for the garden unit. These vegetables were selected based on their vitamin A content, their potential to repel insects and space requirements (Chapter 2, Section 2.6). Closely spaced plants were selected for the garden unit since one garden bed is too small to incorporate enough variety of vegetables if vegetables such as pumpkin and cantaloupe that require large space are included.

The climatic requirements of vegetables determined the choice of vegetables to grow in different seasons (Chapter 2, Section 2.6). Cold tolerant crops such as cabbages, carrots, radish and spinach are grown in cool seasons with optimum temperatures of 15°C to 18°C. Heat tolerant crops such as pepper and tomato are grown in hot seasons with the optimum temperatures of 21°C to 24°C. Water loving plants such as green leafy vegetables are grown in wet seasons and drought resistant crops are grown in dry seasons (FAO 1995a).

The planting times of vegetables selected for the garden unit in cold, warm and hot areas, the time to mature and the harvesting period vegetables are illustrated in Appendix D. In cold areas, planting takes place between August and April with May and June too cold for seedlings to grow well. In warm areas, planting times spread throughout the year, demonstrating that many vegetables may be available all year round. In hot areas, most of the planting is done between February and September. The period between October and January in hot areas is not suitable for the planting of many vegetables due to high temperatures that adversely affect the seedlings. The planting times and harvesting periods of vegetables were plotted in seasonal calendars of twelve months for warm areas (Appendix E). However, in cold, warm and hot areas, at least one or two crops were available even in lean periods, provided the planting times were consistent with the planting guide.

Types of soils also influenced selection of vegetables for the garden unit. Clay soil (heavy soil) was not suitable for root crops as clay soil holds too much water in wet seasons and becomes too dry and hard in dry seasons (Guanzon and Holmer 2002). Sandy soil has poor soil structure and fertility and does not hold water. Sandy soils are suitable for root crops. Therefore, leafy vegetables were suggested for gardens with clay soils and root crops for gardens with sandy soils. However, both clay and sandy soils should be improved by regular application of compost and manure (Gilbert and Hadfield 1987).

3.3 Approaches of the garden unit

Organic methods were integrated in the garden unit to improve the soil structure. Manure and compost need to be dug into the soil to improve the soil organic matter, soil nutrients, and soil water holding capacity and to reduce disease problems (Lindgren *et al.* 1990). Plants such as legumes should be cultivated and turned into the soil to make green manure (Appendix F). Animal manure is dried in the shade and added to the soil (Boyhan *et al.* 1999). Compost is made from kitchen waste such as fruits and vegetable peelings, wood ash, plant residue from home gardens or fields, seeded weeds, animal manure, stalks of sweet-corn, cabbage, broccoli, cauliflower and brussels sprouts (Appendix G) (Gilbert and Hadfield 1987, FAO 1995a). Compost and manure are mixed together or are added to the soil separately to grow healthy plants that are rarely attacked by pests and diseases.

Vegetables selected for the garden unit should be grown directly from seeds or from seedlings (Gilbert and Hadfield 1987). Carrots, beets and radishes are sown directly from seeds and thinned later to allow free growth, as root crops do not transplant properly (Williams *et al.* 1991). Seeds and seedlings of the vegetables selected for the garden unit are sown in holes that are 15 to 20mm deep (Young and Allemann 2002). Two to three seeds should be put in each seed hole made and the seeds are covered with soil. Five to six carrots seeds should be dropped in the hole to render one seed germinating. If more than one seed germinate, the weaker plants should be snipped off with a pair of scissors rather than pulling the plants out as this might disturb the roots of the required plant. Each square should be marked with the contents label to remind gardeners which plants to grow in rotation (Shaw 1998).

The number of plants per square determines plant spacing (Appendix H). Crowded plants may be stunted and leafy vegetables may rot at the base (Williams *et al.* 1991). The plant spacing used for the garden unit is usually recommended on the seed packets. Where the recommended spacing between plants on the seed packets is 30cm, one plant per square should be grown. Four plants per square should be grown where the spacing is 15cm apart, nine plants per square where the spacing is 10cm apart and 16 plants per square should be grown where the plant spacing is 7.5cm apart.

Rotational or successive cropping, companion cropping and cultivation of pest repellent crops should be included in the garden unit to prevent pests and diseases. Crops belong to different families that include: *cruciferous crops*, or cabbage family, *root crops*, *solanaceous crops* and *leguminous crops* (Appendix I) (Gilbert and Hadfield 1987). Vegetables that belong to the same family are planted close to each other to create a scent that is not preferred by some insects. However, plants grown in the garden unit are not far from each other since the unit is small, resulting in a mixture of good and bad companions. Careful trial of companion planting for the garden unit still needs to be carried out by gardeners (Shaw 1998).

Vegetables that belong to the same family should not be planted in rotation or succession since they are attacked by the same pests and diseases. Crops should be rotated with vegetables from different families (Appendix J). *Miscellaneous crops* and *cucurbits* do not fall in the four plant families because they are not attacked by soil-borne diseases and can be planted anywhere in succession or in rotation (Gilbert and Hadfield 1987). Rotation in the garden unit should be automatic because as soon as one crop should be finished, the crop is replaced with a different one to avoid growing the same crops in the same square. However, where there is only one garden unit, it is difficult to rotate crops while adhering to the rule of growing tallest plants at the back and shortest plants in the front (Shaw 1998). However, organic gardeners should rotate crops grown in the garden unit.

Although the legumes provide nitrogen to the soil, which is essential for good plant growth, they were not included in rotation for the garden unit since the garden employed mainly closely spaced plants. *Miscellaneous crops* should be grown where legumes were to be planted in rotation or succession. Use of animal manure from chicken, sheep or cows is recommended for the garden unit to supply nitrogen to the soil.

Vegetables that belong to the cabbage family, spinach and lettuce types require considerable amounts of water, while root crops require little water but require a constant level of moisture (FAO 2001). Crops require more water in hot seasons than cold seasons because of rapid transpiration by plants and evaporation from the soil (Gilbert and Hadfield 1987). Horticultural methods for dry and wet gardening should be employed in the garden unit (Appendix K). Mulching should be was incorporated in the garden unit to conserve soil moisture and to reduce the frequency of watering (Appendix L) (FAO 1995a, 2001). Materials used for mulching include sawdust, leaves, straw, wood shavings, composted materials, animal manure and newspaper (Boyhan *et al.* 1999, Guanzon and Holmer 2002).

3.4 Summary

The garden unit should require little time, income, labour and space compared to traditional gardening. The garden unit should produce high yields in a small space. One garden unit was designed to meet the daily vegetable needs of one person. Thus, the number of household members above one year old determined the number of garden units for each household. The garden unit has 16 equal squares planted with different plants. The quantity of plants per square was determined by vegetable characteristics and the spacing required between plants. The plant spacing was based on the recommendations provided on the seed packets.

Vitamin A in vegetables, planting times, climatic requirements of vegetables, the potential of vegetables to repel pests and soil types determined selection of crops for the garden unit. Soil composting and manuring, rotational or successive cropping and companion planting should be integrated in the garden unit to prevent pests and diseases and to encourage production of sufficient variety of vegetables throughout the year. Water loving plants are planted in wet seasons and drought resistant crops are planted in dry seasons. In dry seasons, mulching conserves soil moisture, which in turn extends the harvesting periods of vegetables. There are plants growing at all times since new and different crops are planted in a squares that had been harvested. The feasibility and acceptance of the garden unit to increase production of vitamin A rich vegetables in study areas is presented in Chapter 5.

CHAPTER 4

STUDY DESIGN AND SAMPLE CHARACTERISTICS

The garden unit described in Chapter 4 was demonstrated to gardeners in Cuphulaka and Mlwandle villages to test its acceptance and feasibility and to collect demographic data among the sample households. The perceptions of the sample households of the acceptance and feasibility of the garden unit are presented in Chapter 5. The vitamin A and vegetable adequacy of the garden unit was tested using the model designed in Chapter 6. The vitamin A and vegetable adequacy of the garden unit is presented in Chapter 7. This Chapter presents the methods and findings of the survey that was conducted in study areas to describe the sample households. The characteristics of the sample areas are reported below.

4.1 Survey methods

A survey was carried out to determine the characteristics of the population on which the model (which will be discussed in Chapter 6) was tested. The feasibility of the garden unit was tested by determining its acceptance among sample households. Data was collected to investigate problems encountered in home gardens, gardening practices employed and frequency of vegetable consumption by sample households.

4.1.1 Population and sample selection

The study was conducted in Cuphulaka and Mlwandle communities in the Camperdown district, in April 2003. These areas were purposively chosen with the help of the Department of Agriculture in Pietermaritzburg on the basis that there are communal gardens and agricultural extension services were offered in these areas, which could contribute to production of vegetables in home gardens. All households that participated in the Department of Agriculture communal vegetable garden projects in these two areas comprised the study population. Household members who were available at the time of the investigation were asked to participate in the study. Twenty-five households in Cuphulaka and 27 households in Mlwandle who participate in the community gardens were included in the study. A total of 52 households were assessed for vegetable production at household level and the frequency consumption of vegetables in two surveys. Most community garden participants were women and this may influence data, but it is typically women who keep household gardens.

4.1.2 Survey materials and approaches

The garden unit was presented to extension workers and horticulturalists at the KwaZulu-Natal Department of Agriculture in March 2003. The extension workers were assured that the study would only test the acceptance and feasibility of the garden unit among sample households in the study areas, rather than conducting a physical trial of the garden. The comments made by extension workers and horticulturalists at the meeting and during informal discussions regarding plant spacing and maturing times of plants were incorporated in the design of the garden unit. Recommendations from the meeting included promoting the garden unit in urban areas where people have less space than in rural areas. After the meeting, the extension workers and technicians arranged opportunities to meet participants of communal gardens in each community.

Six enumerators including agricultural personnel and food security students from Natal University assisted sample members to complete the questionnaires. Prior to data collection, the researcher clarified questions for all enumerators so that they had the same understanding of questions. Individual interviews were conducted among study participants by the enumerators (Figure 4.1). Questions were written in English, translated into Zulu to the study participants and responses were recorded in English by the enumerators. The garden unit was demonstrated to the sample households in Cuphulaka and Mlwandle to test the acceptance and feasibility of the garden among rural households (Figure 4.1). Appendixes A, C, E and J (posters) were used to demonstrate the garden unit to the study participants.

Figure 4.1 Illustrations of individual interviews and the garden demonstration

The study areas were classified as warm areas because the mean annual temperature of these areas is 18°C, ranging from 12.5°C to 24.7°C (Department of Agriculture 2003) and the planting times for warm areas were chosen for the study areas. After demonstration of the garden unit, the study participants were requested to say whether the garden unit was feasible or not feasible by casting an individual vote for "yes" or "no" answer on a flipchart where "yes" represented feasible and acceptable while "no" represented infeasible and unacceptable. Advantages and disadvantages of the garden unit were captured in separate plenary discussions with community garden groups. After the plenary discussions, the enumerators reviewed and analysed the participants' perceptions of the acceptance and feasibility of the garden unit.

4.1.3 Study variables

The study variables are presented in Table 4.1. A survey collected information about household demographics, gardening patterns and vegetable consumption frequency. Data on household composition, household sizes and frequency of vegetable consumption was used to test the vitamin A adequacy from the garden unit. Garden sizes and types of vegetables grown determined whether households currently produce vitamin A rich vegetables on their available land. Organic gardening techniques, choice of crops, socio-economic and environmental problems in home gardens were surveyed to determine their role in vegetable production. The study variables were assessed using the questionnaire presented in Appendix M. The questionnaire took 5 to 10 minutes to complete.

Table 4.1 Study variables

Variables	Measure
Household size and composition •	Required amounts of vitamin A and vegetables by households.
Presence or absence of home gardens	Whether households utilise available space for vegetable production.
Garden size	How much land is available for vegetable production.
Function of the garden	Purpose of home gardening.
Types of vegetables •	Variety of vitamin A rich vegetables grown in home gardens.
Choice of crops	Whether gardeners are aware of nutritional needs of household members.
Socio-economic and environmental constraints to vegetable production	Factors contributing to low production of vegetables in home gardens.
Gardening practices	Whether households currently apply organic methods in vegetable production.
Food frequency •	Number of times vegetables and animal foods of are included in family diets
• variables that are employed in model.	

4.1.4 Data treatment and analysis

Survey data was analysed using SPSS version 11.0 (Appendix N). Frequency counts were drawn for household composition and size, presence or absence of home gardens, garden sizes, choice of vegetables, types of crops grown, gardening practices, garden function, period when there are no vegetables in the garden, problems encountered in garden activities and frequency of food consumption. Although it may have been insightful to compare the difference between means and responses given, it was not possible given the small sample size. Demographic data and frequencies of vegetable consumption were used in the simulation model presented in Chapter 6.

4.2 Sample characteristics

The study was carried out in Cuphulaka and Mlwandle villages in the Camperdown District, KwaZulu-Natal. Figure 4.2 illustrates the types of houses found in both Cuphulaka and Mlwandle villages. The map KwaZulu-Natal is provided Appendix O to demonstrate the location of the study areas. Cuphulaka is located in the Valley of a Thousand Hills and Mlwandle is found in Umvoti district.

Figure 4.2 Types of homesteads found in Cuphulaka and Mlwandle

The climatic conditions of the area determine production and types of crops grown (FAO 1995a). Rainfall in Cuphulaka ranges from 5mm to 125mm a month and 4mm to 111mm in Mlwandle (Department of Agriculture 2003). The annual rainfall is 836mm and 735mm in Cuphulaka and Mlwandle respectively. The annual mean temperature for both areas is about 18°C ranging from 12.5°C to 24.7°C (Department of Agriculture 2003), indicating that vegetables such as cabbages, carrots and spinach, which require optimum temperatures of 15°C to 18°C and pepper and tomato, which require 21°C to 24°C (FAO 1995a) can grow well in these areas. Cuphulaka does not experience frost while Mlwandle experiences occasional frost.

Sources of water include potable water inside the house, potable water onsite, public taps, boreholes and natural water such as springs, rivers and rain tanks (Department of Agriculture 2003). The majority of households in study areas use natural water sources. Crops such as cabbage, carrots, tomato, beans, maize, sorghum, soybeans, potatoes, cowpea and sugarcane grow well in Cuphulaka and Mlwandle. Banana grows in Cuphulaka while groundnuts grow well in Mlwandle (Department of Agriculture 2003).

There are marginal differences in the potential yields of crops that could be grown in Cuphulaka and Mlwandle (Department of Agriculture 2003). The potential yields of crops depend on soil types and the level of crop management engaged. Cabbage could yield from 28.2 to 58.1 tons per hectare. The potential yield of carrots is estimated at 30.9 to 52.7 tons per hectare. The potential yield of tomato ranges from 20.8 to 41.6 tons per hectare in Cuphulaka. Thus, given fertile soil types and good crop management, vegetables such as cabbage, carrots and tomato can yield fairly in study areas (Department of Agriculture 2003).

Income levels play an important role in household food security because income determines purchasing power (FAO 1997). Households with higher incomes have better opportunities to access food and agricultural inputs compared to households with low purchasing power. In the districts where Cuphulaka and Mlwandle villages are located, about 15 percent of households and 58 percent of individuals have no incomes (Department of Agriculture 2003). This may have a negative impact on household food security as only seven percent of household are engaged in subsistence farming (Department of Agriculture 2003).

4.3 Sample household size and composition

Household size determined the number of garden units required by each household since one garden unit was designed to meet the vegetable needs of one household member. Household composition was required to measure the vitamin A requirements based on age, sex and physiological status of household members. Household sizes in study areas ranged from two to 31 people (Figure 4.3). The mean household size was eight. Two households had 30 and 31 people members each. Extremely large household sizes may raise concern, as it may not be feasible to establish garden units of this size where there is little land available, although land is generally available in the two study areas. Women aged 15 to 49 comprised the majority of the participants of the communal gardens in study areas.

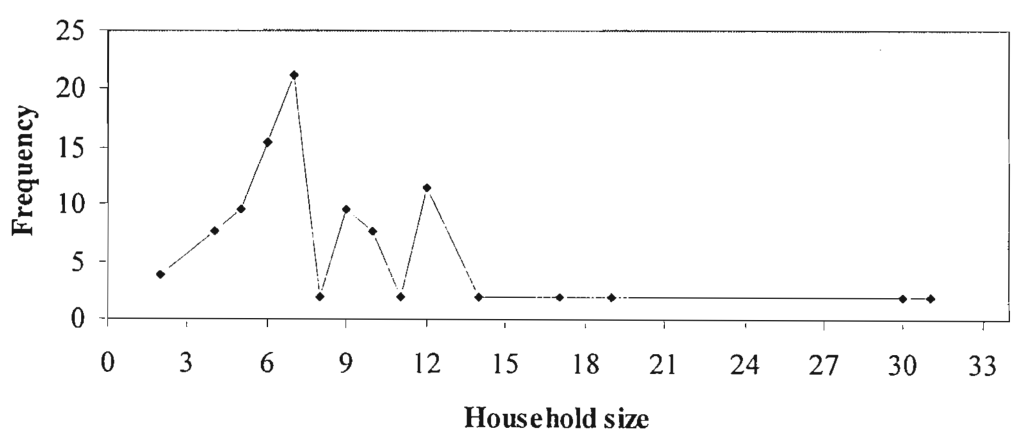

Figure 4.3 Number of people in sample households, Cuphulaka and Mlwandle, 2003, (n=52)

The sample size was 52 households, rendering 453 household members. In both Cuphulaka and Mlwandle, women of childbearing age (15 to 49 years) constituted 30 percent of household members (Table 4.2). The number of women ranged from one to 19 in individual households, with 12 and 19 women appearing in the biggest households (30 and 31 members respectively).

Table 4.2 Composition of the sample households in Cuphulaka and Mlwandle, 2003, (n=453)

Household composition	% of household members in Cuphulaka (n=212)	% of household members in Mlwandle (n=241)	% of total sample (n=453)
Infants	2	5	4
Preschoolers	13	9	11
Scholars (6-14 years)	22	24	23
Women of child bearing age	27	31	30
Pregnant women	0	1	0
Lactating women	1	2	2
Women aged 50 years +	11	8	8
Men aged 15 years+	24	20	22
	100	**100**	**100**

Children 6 to 14 years comprised 23 percent of sample population, while men aged 15 years and above made up 22 percent of the sample population. Children 1 to 5 years old comprised 11 percent while women above 50 years old made eight percent of household population in study areas. Of the 17 children under one year old (4 percent of population) 12 percent were breastfed.

4.4 The functions of home gardens in Cuphulaka and Mlwandle

Whether households had home gardens or not was used to establish whether households used available land for vegetable production. Seventy-five percent of sample households did not have home gardens (Table 4.3). Of households with gardens, 31 percent came from Cuphulaka and 69 percent came from Mlwandle. Home gardens ranged from $30m^2$ to $200m^2$. Thirty-six percent of gardens ranged from $6m^2$ to $30m^2$. Another 36 percent of home gardeners had garden sizes of $100m^2$ while 27 percent reported gardens of $200m^2$, indicating access to enough land to grow vegetables.

Table 4.3 Percentage of sample households by presence and absence of home gardens, Cuphulaka and Mlwandle, 2003, (n=52)

Home garden	% of sample households in Cuphulaka (n=25)	% of sample households in Mlwandle (n=27)	% of total sample households (n=52)
Present	16	33	25
Absent	84	67	75

Sixty percent of home gardeners grow vegetables mainly for household consumption while 40 percent grow vegetables to consume and to sell the surplus. Home gardeners reported that they buy vegetables in autumn and winter, as they do not have vegetables in their gardens at these times. Only 20 percent of home gardeners have vegetables in home gardens throughout the year. It must be noted that the survey was conducted in April when many households reported that they did not have vegetables in home gardens and had just started planting for the next season. The respondents also reported that January to March was too hot for plants to grow well.

More than half the home gardeners grow vegetables because it is cost-effective and saves money to buy other food items. Thirty-one percent said they grow vegetables to increase variety of food in family diets while another 31 percent grow vegetables to obtain adequate nutrients. Twenty-three percent of home gardeners grow vegetables to alleviate hunger. Another 23 percent of gardeners reported that they have adequate time to carry out the gardening activities. Extension services and water availability are each reported by 15 percent of gardeners as driving forces for home gardening. These figures indicate that the sample households perceive food gardens as useful.

4.5 Socio-economic and environmental factors that undermine vegetable production in home gardens in Cuphulaka and Mlwandle

Households without home gardens reported various factors that lead to non gardening. Sixty-six percent of households without home gardens reported lack of water in the study areas as the strongest inhibiting factor to vegetable production. Sixty percent of households without home gardens reported lack of fencing as the constraint to vegetable production in home gardens, as animals damage plants in the gardens and so they were discouraged about gardening (Figure 4.4).

Although lack of access to land, lack of time, poor soils, limited labour and lack of skills and knowledge were also reported to discourage home gardening in the study areas. The fact that all sample households participate in communal gardens does not prevent them from having home gardens, as only less than five percent of households without home gardens reported that they do not have home gardens because they participate in community gardens.

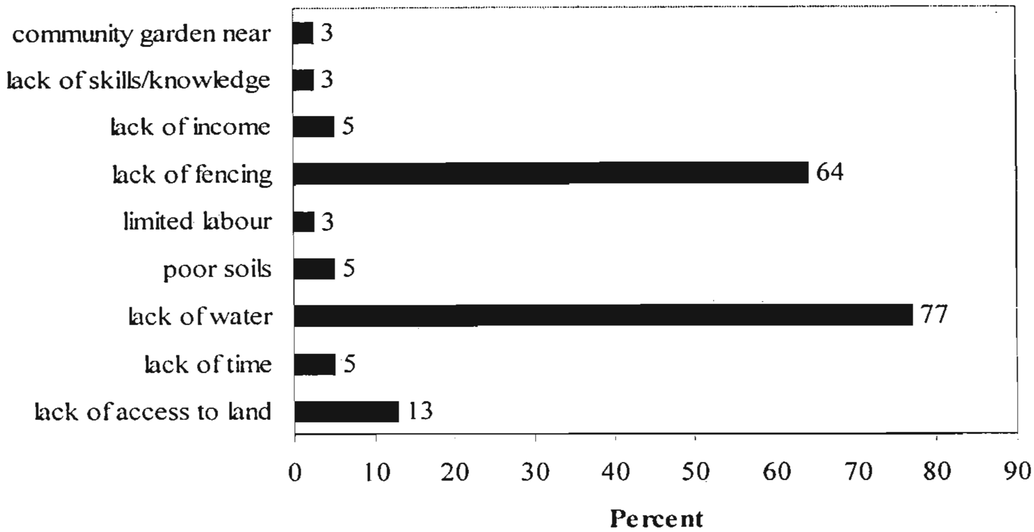

Figure 4.4 Reasons for not having home gardens by percentage of households without home gardens, Cuphulaka and Mlwandle, 2003, (n=39)

Factors that limit vegetable production in home gardens were surveyed among home gardeners to determine the extent they play in home gardens. Water scarcity, animal interference and plant diseases were the commonly encountered problems reported by home gardeners (Figure 4.5).

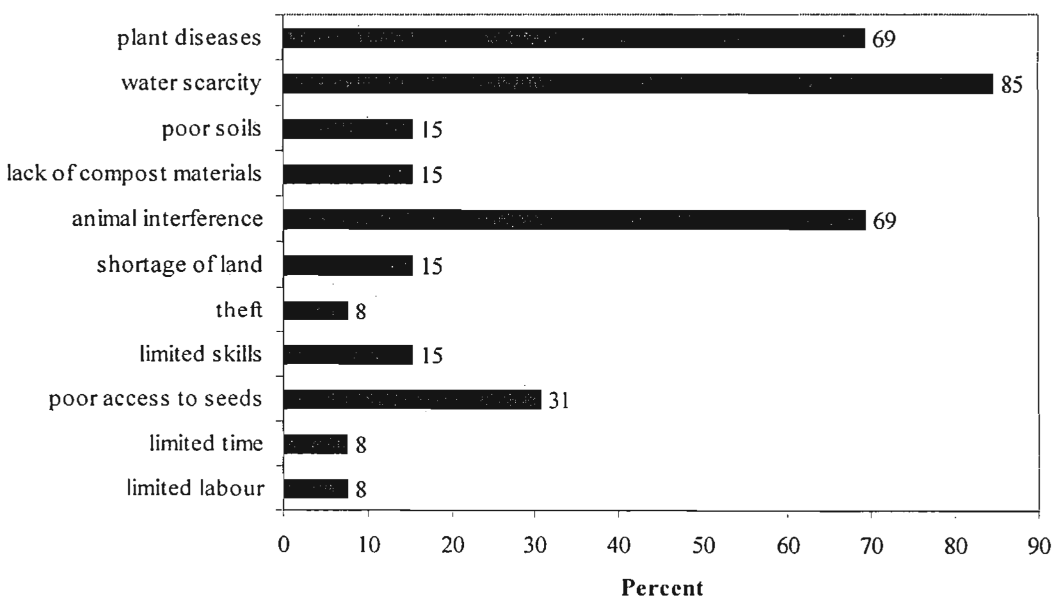

Figure 4.5 Factors that limit vegetable production by percentage of home gardens, Cuphulaka and Mlwandle, 2003, (n=13)

These reasons were the same as given by households without home gardens. Use of synthetic chemicals simultaneously with application of organic farming methods is common among sample home gardeners. Other factors that limit home gardening such as poor soils, lack of compost materials, limited skills and shortage of land were each reported by 15 percent of home gardeners. Labour, time and theft do not seem to hinder vegetable production since less than ten percent of home gardeners considered them as constraints, while less than five percent of households without home gardens reported them as causal factors of non- gardening.

4.6 Types of crops grown in home gardens in Cuphulaka and Mlwandle

The type of vegetables grown in home gardens was used to establish whether households produce vitamin A rich vegetables included in the garden unit. The five most important crops grown include: maize, beans, spinach, tomato and carrots (Figure 4.6). Beans and maize were grown by more than 60 percent of households. Between 23 and 54 percent of home gardeners grew beets, carrots, chinese cabbage, onion, pepper, swiss chard and tomato.

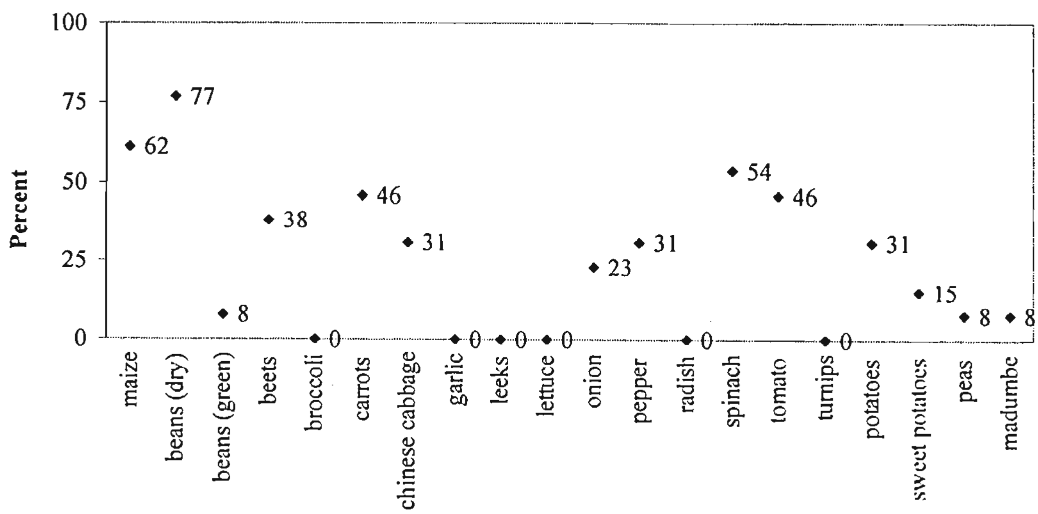

Figure 4.6 Production of crops in home gardens over the last year by percentage of home gardeners, Cuphulaka and Mlwandle, 2003, (n=13)

Sixty-one percent of home gardeners reported that their choice of crops for home gardening is influenced by availability of seed (Figure 4.7). Seed may be easily available from neighbours or relatives especially in rural areas. Sometimes few shops are available in the area and may sell similar types and fewer varieties of seeds, thus influencing production of vegetables.

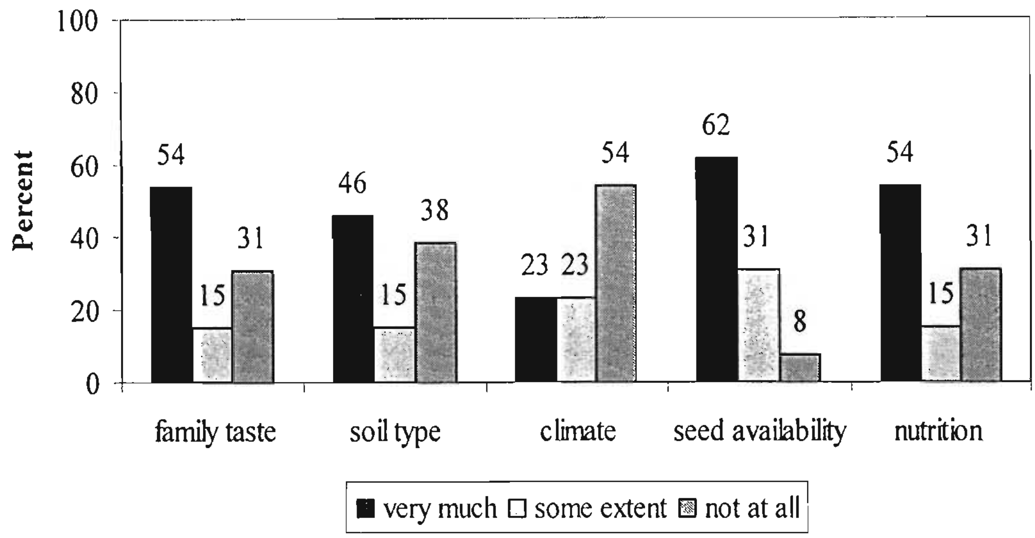

Figure 4.7 Factors that determine choice of crops by percentage of home gardeners, Cuphulaka and Mlwandle, 2003, (n=13)

Other factors that influence the choice of crops among home gardeners include family taste (54%), nutrition considerations (54%) and soil types (46%). Climate was not reported as an important factor that determines the choice of crops among home gardeners, yet eighty percent of gardeners stated that excessive heat in January to March prevented vegetable production and few grew vegetables in autumn and winter.

4.7 Gardening methods applied in home gardens in Cuphulaka and Mlwandle

The current gardening practices employed by home gardeners in study areas assessed whether households applied organic farming methods to increase the variety of vegetables and extend the harvesting periods of vegetables. All sample home gardeners used animal manure to improve soil structure (Table 4.4). None of the sample households used green manure. Soil composting was applied by only eight percent of home gardeners while 23 percent used synthetic fertilisers in their gardens concurrently with natural fertilisers.

Table 4.4 Percentage of home gardeners by measures of soil improvement, Cuphulaka and Mlwandle, 2003, (n=13)

	Frequency of households	% of home gardeners
soil compost	1	8
animal manure	13	100
green manure	0	0
synthetic fertilizers	3	23

Sixty-two percent of the sample home gardeners rotated crops, 39 percent removed diseased crops from the garden to prevent diseases from spreading to other crops and 31 percent use ash to control pests and diseases (Figure 4.8).

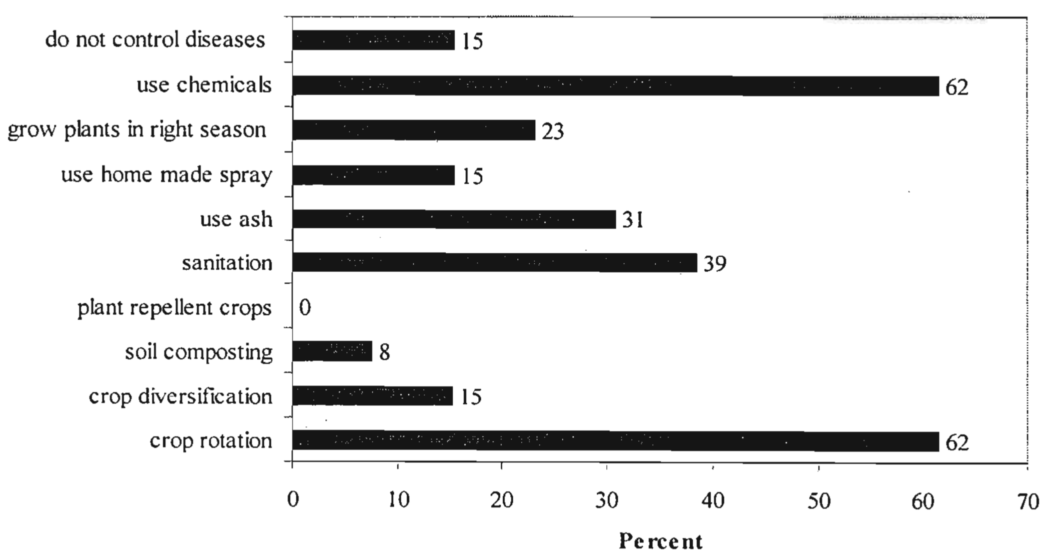

Figure 4.8 Pest and disease control measures by percentage of home gardeners, Cuphulaka and Mlwandle, 2003 (n=13)

In addition to crop rotation, sanitation and use of ash to control pests and diseases, 62 percent of home gardeners used chemicals to prevent pests and diseases in their gardens. As only eight percent of gardeners used compost to improve soil structure, a similar proportion of sample home gardeners use soil compost to prevent pests and diseases. Diseases must limit vegetable production since 15 percent of home gardeners reported that they do not control pests and diseases in their gardens. Weeds compete with vegetables for nutrients and moisture and thus have to be removed. Sixty-nine percent of home gardeners remove weeds by hand. Twenty percent mulch their gardens to prevent weed growth, while eight percent use hoes to remove weeds. None of home gardeners grow plants close together to control weed growth.

4.8 Consumption of vegetables by sample households in Cuphulaka and Mlwandle

Food frequency method was used to measure the number of times selected foods were included in family diets. All households with or without home gardens were included in the assessment of frequency of food consumption. Tomato and onions were widely consumed by the sample households (Figure 4.9). Onion was consumed daily by 60 percent of households and tomato was consumed daily by 50 percent of households.

All sample households consumed onions at least once per week, yet only 23 percent of home gardeners produced onion. Ninety percent of sample households consumed tomato at least once per week, while only 11 percent of sample households produced tomato. The comparison between production and consumption of onion and tomato indicates that vegetables consumed by sample households do not come from home gardens alone, but also from community gardens while many households purchase vegetables, particularly in autumn and in winter.

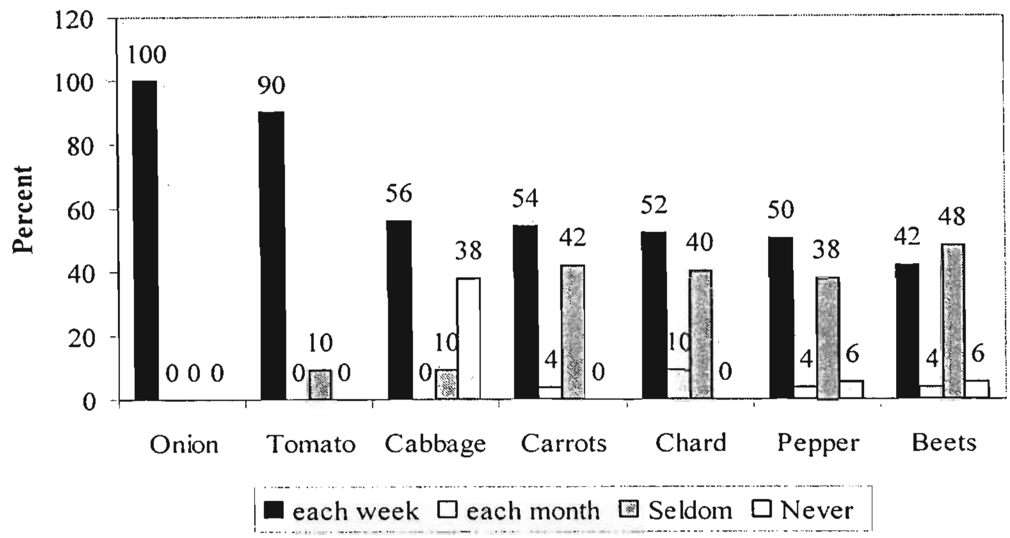

Figure 4.9 Proportion of consumers of vegetables, Cuphulaka and Mlwandle, 2003, (n=52)

The frequency of consumption of beets, carrots, chinese cabbage and spinach was one to three times per week among households who consumed these vegetables. Thirty-five percent of sample households never consumed cabbage indicating that cabbage is not a preferred vegetable among sample households or it is not widely produced in these areas. More than 70 percent of the sample households in study areas never consumed broccoli, lettuce, radish, turnips and leeks. There is no difference in the consumption of vegetables between households with home gardens and households who depend mainly on communal gardens. Consumption of vitamin A rich vegetables among households lack variety and the frequency consumption of these vegetables is low.

4.9 Consumption of vitamin A rich animal foods by sample households in Cuphulaka and Mlwandle

Nel and Steyn (2001) have identified milk, eggs, fish and beef offal as possible vitamin A rich food items of animal origin consumed by rural households. Thus, the frequency consumption of milk, fish, beef offal and eggs was investigated among sample households to evaluate whether frequency consumption of these foods was comparable to the intakes of South African rural households in Nel and Steyn (2001).

Eggs and milk were included in family diets by 83 and 63 percent of sample households respectively at least once per week (Figure 4.10). Beef offal and fish were consumed at least once per week by 45 and 25 percent of households respectively. Twenty-five percent of households reported that they do not consume fish and 12 percent does not consume milk. The findings of this study indicate that eggs are the most frequently consumed vitamin A rich protein (83%) as compared to eight to 14 percent of egg consumers in Nel and Steyn (2001).

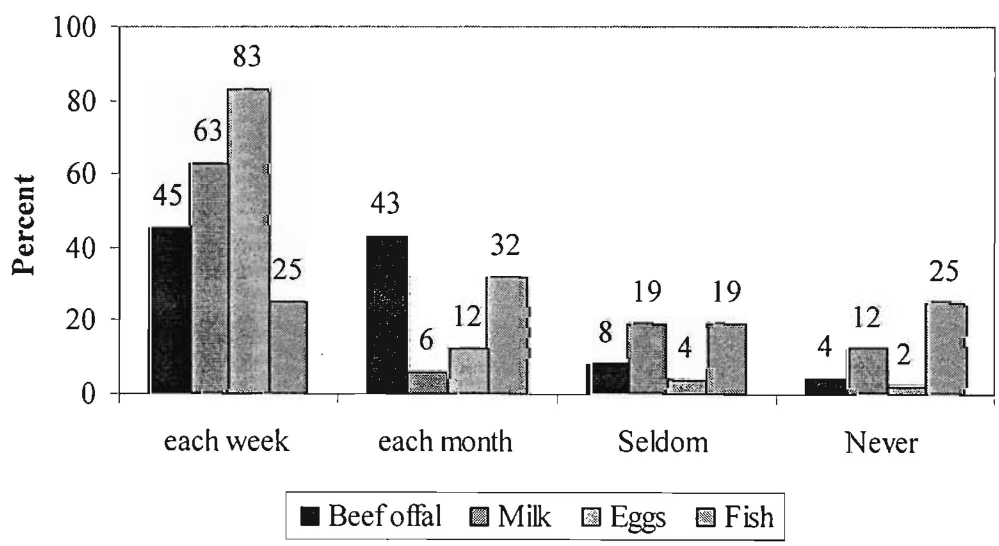

Figure 4.10 Proportion of consumers of vitamin A rich animal foods, Cuphulaka and Mlwandle, 2003, (n=52)

The quantity of milk and eggs consumed by children under five was assessed to determine adequacy of consumption of these foods. Among children under five years old, 84 percent consumed eggs and 57 percent consumed milk at least once a week or once a month. One egg per day is recommended for children aged 2 to 6 years old

(NICUS undated b). Forty-nine percent of children aged one to five years consume at least one egg per day (Figure 4.11). Sixteen percent of one to five year olds consume two eggs per day, while 19 percent of this age group consume three to five eggs per day, indicating excess intake of eggs among children aged 1 to 5 years in sample households at the time of the survey.

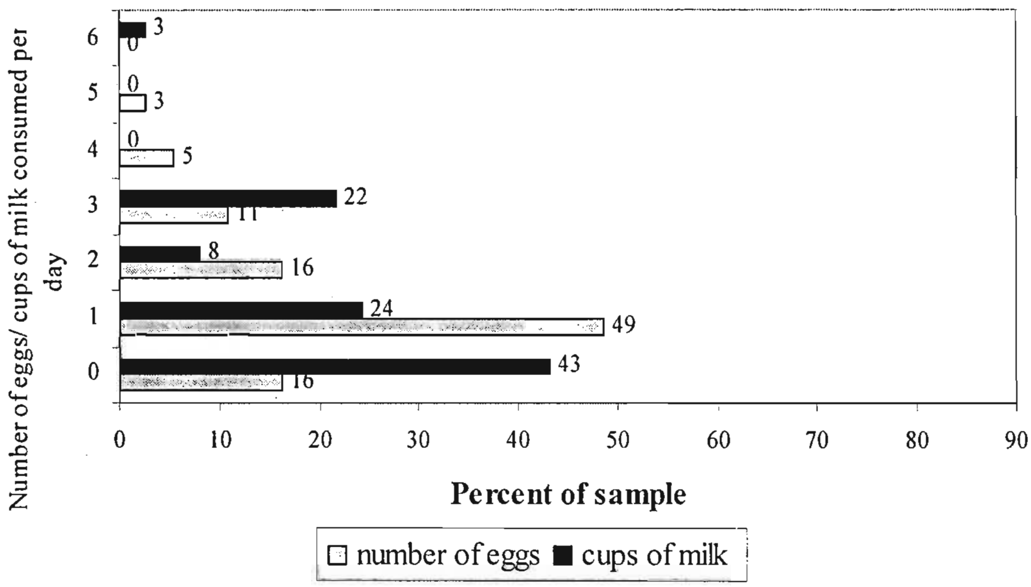

Figure 4.11 Quantity of eggs and milk consumed daily by children aged 1 to 5 years old, Cuphulaka and Mlwandle, 2003, (n=37)

Children aged between two and three years old require half a cup (125ml) of milk and four to six year olds require half a cup (125ml) to three quarter cups (185.5ml) per day. Twenty-four percent of children in sample households drink at least one cup (250ml) of milk per day (NICUS undated b). Thirty-eight percent of 1 to 5 year olds drink two to three cups of milk per day. Three percent of sampled 1 to 5 years olds consume six cups of milk per day. Although milk is frequently recommended for children under five years old, it should not exceed 600ml per day (NICUS undated b).

Consumption of eggs and milk among children 1 to 5 years old in sample households is high since the majority consume at least one egg or one cup of milk per day, sometimes they consume more than the minimum requirements. Children aged 1 to 5 years consumed eggs more frequently than milk. However, there is a possibility that the quantities of eggs and milk consumed by children in study areas were under or over estimated, as these foods were not weighed.

4.10 Summary √

Few households in Cuphulaka and Mlwandle have home gardens, but depend mainly on communal vegetable garden projects for vegetables. Households without home gardens have identified water scarcity and lack fencing as major contributing factors to non gardening. Similarly, home gardeners frequently reported water scarcity and animal interference in home gardens due to lack of fencing as the main constraints to vegetable production. The literature has also shown that water scarcity limits vegetable production in many South African rural households. In addition to water scarcity and lack of fencing, diseases and poor access to seeds were reported as important factors that result in low vegetable production in home gardens. Insufficient time and labour, and limited garden management skills also play a role the limited home gardening.

Although the sample households recognised the potential of the home gardens for nutritional supplementation, few households produce and consume a variety of vitamin A rich vegetables. The sample home gardeners produce vegetables to vary family diets, alleviate hunger and to save money usually used to buy vegetables. However, production of vegetables by sample households is characterised by seasonal the production, low yields and lack of variety, indicating under-utilisation of the potential of available land.

Production of maize and beans is apparently considered more important by sample households than the production of the vegetables. The most commonly produced vegetables in home gardens included spinach, tomato, carrots, beets, cabbage, pepper and onion. Sample households with home gardens never produce broccoli, turnips, radish and lettuce. Of the organic methods that encourage variety of vegetables produced, crop rotation is employed by many home gardeners. Few sample home gardeners diversify crops, resulting in insufficient variety of vegetables. The findings indicate that sample gardeners do not have knowledge and skills of organic production methods, especially to control pests and diseases.

The results of this study compare favourably to the review of vegetable production and consumption by Webb (2000) as sample households with home gardens do not necessarily consume vegetables more frequently than households who do not keep home gardens. Webb (1996 cited by Webb 2000) noted that households in the Eastern Cape consumed small amounts of vegetables, about two to three times per week. Occasionally, consumption of vegetables among households with gardens may be higher than of households without gardens, but the increased frequency of consumption of vegetables is often not significant (Webb 2000).

Eggs and milk are frequently included in family diets by sample households and are commonly consumed by children aged 1 to 5 years. Fish is the least consumed animal food. Many households only consume beef-offal once per month. Children aged 1 to 5 years old in sample households often consume more eggs and milk than the minimum requirements.

CHAPTER 5

ACCEPTANCE AND FEASIBILITY OF THE GARDEN UNIT BY HOUSEHOLDS IN CUPHULAKA AND MLWANDLE

The garden unit (designed in Chapter 3) aims at increasing production of vitamin A rich vegetables in home gardens. The garden unit was demonstrated to the sample households to test its acceptance and feasibility by sample households. Data from the survey is presented in Chapter 4 and was used to analyse the gardening patterns amongst the sample households. This chapter presents the potential of the garden unit in overcoming the constraints of home gardening reported by sample households. The sample households' perceptions of the acceptance and feasibility of the garden unit are outlined below.

As sample households ranged in size from two to 31 household members, sample households require gardens between $2.44m^2$ and $37.82m^2$ (each garden unit is $1.22m^2$). Home gardeners reported household gardens ranging from $6m^2$ to $200m^2$. This indicates the units are larger than what households currently have, that is, current production is inadequate.

The garden unit attempts to overcome the reported water scarcity for home gardening by recommending use of kitchen water waste in the garden and mulching to conserve soil moisture, which minimises the number of times plants are watered (Table 5.1). The use of shrub branches and cabbage or orange bags for fencing the gardens is employed to prevent animals from interfering with the garden plants.

Table 5.1 The potential of the garden unit in overcoming the reported home gardening constraints in Cuphulaka and Mlwandle, 2003

Reported constraints to home gardening by sample households in study areas	The garden unit measures to overcome constraints to home gardening
Water scarcity	Mulching is applied to conserve soil moisture, Kitchen water waste is used to minimise demand for water for garden use, Soil is improved to increase soil water holding capacity.
Lack of fencing	Shrub branches, cabbage and orange bags are used to fence the garden.
Poor soils	Soil compost, green and animal manure are used to increase soil structure.
Plant diseases	Crops are diversified and rotated to prevent pests and diseases. Soil structure is improved to produce healthy plants that are less troubled by pests and diseases
Limited time and labour	Watering is minimal due to mulching and soil improvement measures, Weeding is minimal due to mulching and plants grown close to each other to prevent weed growth.
Seasonal production	New plants are grown all the time to replace harvested ones.
Little variety of vegetables produced	Rotational and companion cropping increase variety of vegetables produced.

Little time and labour are required to maintain the garden unit/s as watering and weeding are minimal. The garden unit recommends use of soil compost and manure to improve the reported poor soil types, to produce healthy plants that are not likely attacked by pests and diseases, and to increase soil water holding capacity. The use of animal manure in home gardens is common among sample home gardeners. However, many sample households use synthetic fertilisers, pesticides and herbicides, which are not recommended for the garden unit as these chemicals are may not be safe for health and the environment. Instead, application of rotational and companion cropping is recommended in the garden unit to eliminate pests and diseases from vegetables, using safe and cheap methods, which in turn increase the variety of vegetables produced in the garden. Many home gardeners are already familiar with crop rotation, but few households diversify crops, indicating a need to encourage organic gardening methods among sample households. C rop r otation a nd d iversification e ncourage p roduction o f vegetables in all seasons while preventing pests and diseases in home gardens.

A number of vegetables selected for the garden unit are already grown by sample households with home gardens (Table 5.2), and so households are already familiar with these vegetables. Some diversity of vegetables was evident in home gardens, but individual home gardeners grow insufficient varieties of vitamin A rich vegetables. Broccoli, lettuce, turnip and radish are not produced in home gardens in study areas because they are not considered as cultural food. However, sample households were keen to know how to produce and prepare these vegetables.

Table 5.2 Crops selected for the garden unit, crops grown and crops not grown in home gardens, Cuphulaka and Mlwandle, 2003, n=13

Vegetables	
Included in the garden unit	Beets, broccoli, carrots, Chinese cabbage, garlic, leeks, lettuce, onion, pepper, radish, spinach, tomato and turnips.
Included in garden unit and grown	Beets, carrots, cabbage, onion, pepper, spinach and tomato.
Included in the garden unit, but not grown	Broccoli, garlic, leeks, lettuce, turnips and radish.
Not included in the garden unit, but grown	Maize, beans, potatoes, sweet potatoes, peas and madumbe.

The sample households were keen to implement the garden unit, given the perceived potential of the garden unit to increase the variety of vegetables, using cost-effective methods. The respondents reported that the garden design motivated them to carry out gardening activities, encouraging production of a diversity of vegetables on small plots of land, adding variety to family diets. Little weeding and watering are required and these would save time and labour. The sample households regarded the garden unit simple to maintain and considered the guidelines provided easy to understand and follow.

The sample households reported few disadvantages regarding the garden unit. The greatest weakness perceived was inefficiency of the garden unit to produce surplus produce for sale. The study households reported that gardening is more important when households benefit in terms of food for consumption and for sale. Sample households were enthusiastic to save money through producing rather than buying vegetables, but also wanted to generate income. Although broccoli, garlic, leeks, turnips and radish are not typically produced and consumed by the sample households, all the gardeners reported that they could produce these vegetables if the extension agents demonstrated how to grow and prepare the vegetables they were not familiar with. The fact that sample households participated in the communal garden projects, does not prevent households from keeping home gardens. Since most communal gardens were collections of individual plots, the garden units could be extended to the production of the communal gardens. Sample households accepted the garden unit and found it feasible to increase production of a variety of vegetables in home gardens.

5.1 Summary

The sample households in study areas have enough land to implement the garden unit/s. The garden unit attempts to minimise factors that limit vegetable production in home gardens. First, application of mulching, use of kitchen water waste and horticultural practices for dry gardening are incorporated in the garden unit to overcome the reported water scarcity. Second, shrub branches, cabbage and orange bags are recommended in the garden unit to provide fencing to prevent animal interference with plants in home gardens. Third, soil compost and animal and green manure should be dug into the soil to improve the reported poor soil types in home gardens and to increase soil water holding capacity. Fourth, crops should be rotated and diversified to prevent pests and diseases frequently reported by gardeners, while minimising the costs incurred in the purchase of synthetic fertilisers and chemicals. Fifth, the garden unit requires little time and labour as plant watering and weeding are minimal.

Some vegetables selected for the garden unit are already produced in home gardens by the study participants. However, training is required to enable sample households to produce vegetables that are not yet grown. The potential of the garden unit to overcome prevailing constraints to home gardening in study areas was visible. Given that households accepted the garden unit and found it feasible to increase production of vegetables in home gardens, the garden unit should be included in strategies to increase vegetable production.

CHAPTER 6

EVALUATION MODEL

An evaluation model was developed to establish the contribution of the garden unit to the vitamin A and vegetable needs of low-income households, especially in rural areas. The literature revealed that vitamin A for household consumption can be obtained from a variety of foods including animal foods such as eggs, liver and milk; fortified foods such as margarine, maize meal and oil; and plant foods including green leaves, orange and yellow fruits and vegetables (FAO 1997). To develop an evaluation model, vitamin A rich foods from animal sources, fortified, and plant foods that are commonly consumed by rural South Africans were identified from Nel and Steyn (2001).

Nel and Steyn (2001) indicated that different age groups among rural South Africans typically consume milk, eggs, fish, beef offal and maize porridge, while few people consumed fruits. South African rural populations typically consume fruits only when they are locally available, mainly when in season. Low consumption of fruits is a result of inaffordability by low-income households (Love and Sayed 2001). Thus, the possible contribution of food items commonly consumed by typical rural households of vitamin A intakes was determined from milk, eggs, fish, beef offal and maize meal. This section gives an overview of the process employed to compute vitamin A intakes of sample households to approximate amounts of vitamin A that the garden units could contribute to RDA of sample households.

6.1 Determination of average vitamin A intake from animal foods in rural South Africa

Vitamin A rich animal foods commonly consumed by more than three percent of rural South Africans were identified from the South African food consumption studies undertaken amongst different population groups (1983-2000) (Nel and Steyn 2001). Cows milk has relatively low vitamin A content compared to eggs and beef offal (Blum *et al.* 1997) (Table 6.1). Yet milk is more consumed among South African rural households than other vitamin A rich animal foods (Figure 6.1).

Table 6.1 Vitamin A content of animal foods consumed in rural South Africa (Blum *et al.* 1997)

Foods of animal origin	RE per 100g
Milk	30-40
Fish	11-100
Eggs	260
Beef offal (liver and kidney)	800

RE refers to Retinol Equivalent.

Forty five percent of children aged 1 to 5 years, 32 percent of children aged 6 to 9 years and 20 percent of people over ten years old in rural South Africa consume milk (Nel and Steyn 2001). Less than ten percent of children aged 1 to 9 years old and 14 percent of people above ten years old in rural households consume eggs (Figure 5.2). Five egg-yolks contain slightly more vitamin A than half the requirements of children aged 1 to 5 years old (400RE).

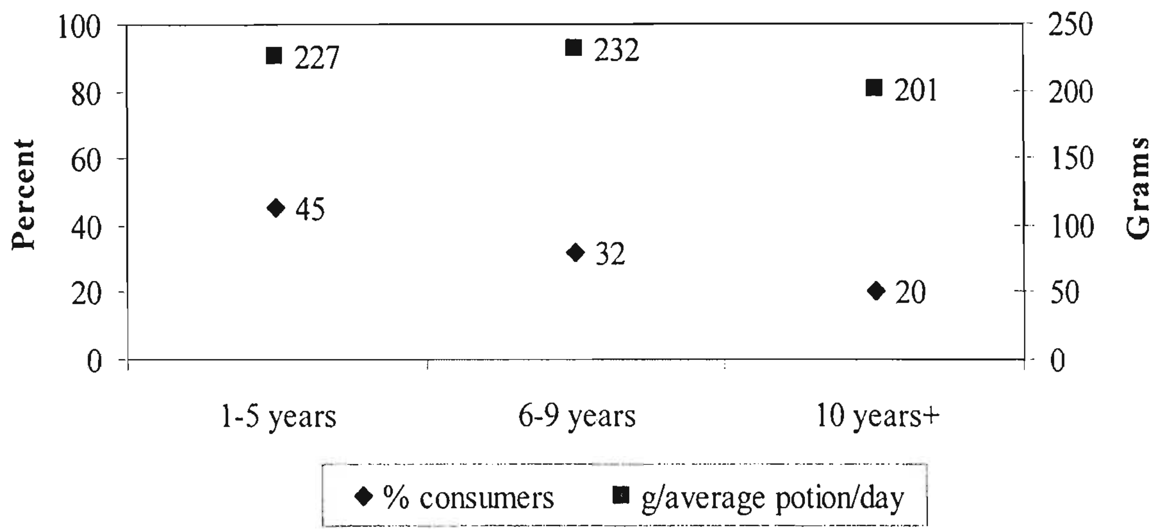

Figure 6.1 Consumption of milk by rural South Africans, 1999 (adapted from Nel and Steyn 2001)

Less than 10 percent of rural South Africans consume fish (Figure 6.3). The vitamin A content of fish is lower than that of eggs and beef offal and sometimes less than that of milk, depending on the type of fish consumed (Blum *et al.* 1997).

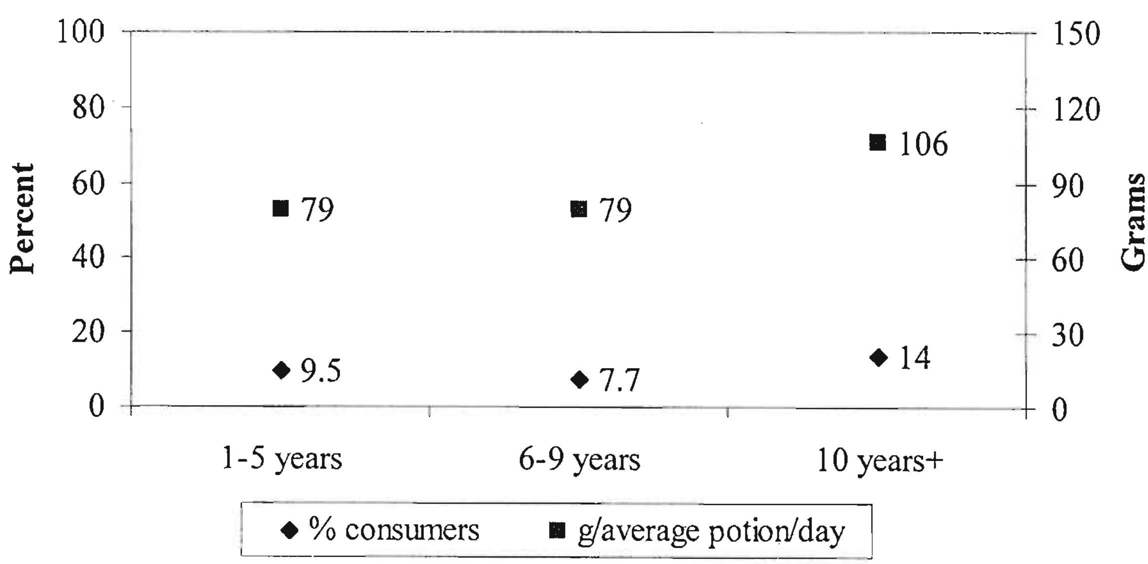

Figure 6.2 Consumption of eggs by rural South Africans, 1999 (adapted from Nel and Steyn 2001)

Beef liver and kidney contain high vitamin A per 100g of edible portion that can satisfy the requirements of an adult (600RE) since 100g contain 800RE (Blum *et al.* 1997). However, beef offal is consumed by less than three percent of rural South Africans who commonly consume beef offal only once a month (Figure 6.4).

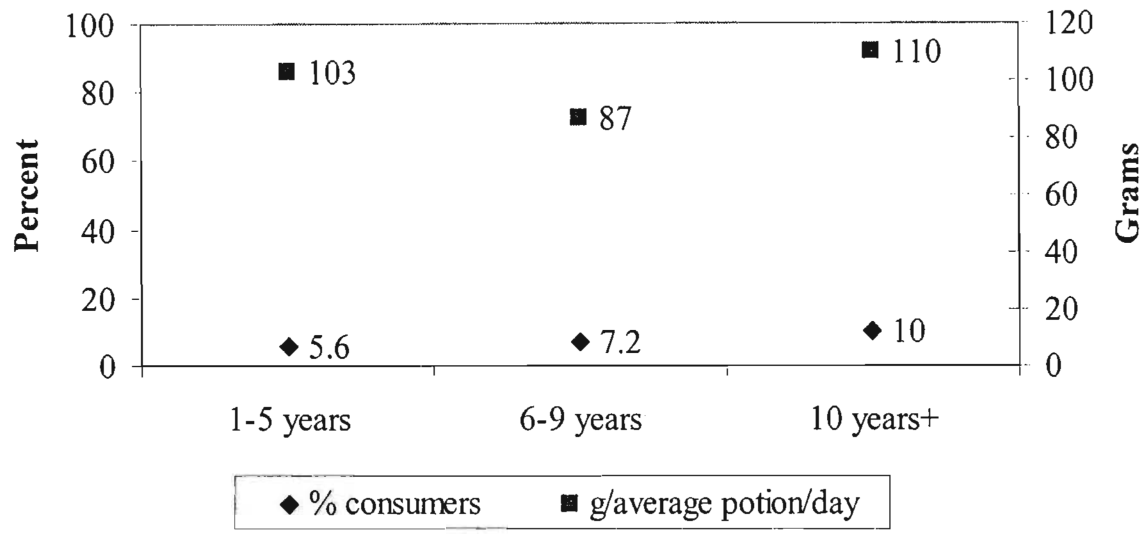

Figure 6.3 Consumption of fish by rural South Africans, 1999 (adapted from Nel and Steyn 2001)

Consumption of protein rich foods high in vitamin A among rural South Africans is low (Nel and Steyn 2001). Although children aged 1 to 5 years old consume milk more frequently than eggs, the contribution of eggs to the vitamin A intake of consumers for this age group is 51 percent of their requirements compared to 26 percent of RDA of vitamin A provided by milk (Table 6.2).

To estimate the vitamin A typically consumed from milk, eggs and fish by children aged 1 to 9 years in rural households, the proportions of vitamin A consumed from these foods to the RDAs were calculated. Although beef offal has high vitamin A, the proportion of rural people who consume beef offal was small (Nel and Steyn 2001). Therefore, beef offal was not included in the estimation of vitamin A from vitamin A rich animal foods.

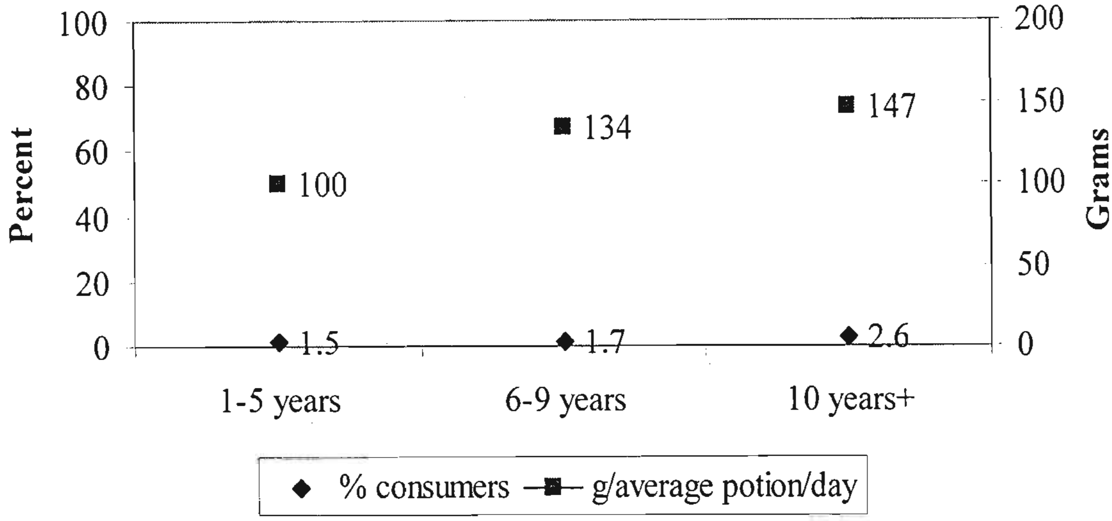

Figure 6.4 Consumption of beef offal by rural South Africans, 1999 (adapted from Nel and Steyn 2001)

The percentage RDAs were computed by multiplying the vitamin A content of milk, eggs and fish (per 100g of edible portions) with the portion sizes typically consumed by different age groups. Then vitamin A provided by the portion size of each food consumed by 1 to 5 year olds and 6 to 9 year olds was divided by the respective vitamin A requirements provided by FAO (2001).

Table 6.2 The percentage of vitamin A of RDA from animal foods for 1 to 9 year olds in South African rural households, 1999 (Nel and Steyn 2001)

Age groups	RE required	Milk		Eggs		Fish		Average RE intake	
		RE/ portion	% RDA	RE/ portion	% RDA	RE/ portion	% RDA	RE/ portion	% RDA
1-5	400	102	26	205	51	58	15	121	30
6-9	600	104	17	205	34	49	8	119	20
Average % of RDA for vitamin A									25%

The average vitamin A consumed from animal foods was estimated to be 25 percent of the RDA, which is less than half the requirements of children aged 1 to 9 years old. The contribution of vitamin A intake from non-vegetable food sources was estimated among South African rural children aged 1 to 9 years because vitamin A deficiency is more prevalent in rural areas and among children (Bonti-Ankomah 2001, de Hoop *et al.* 2002).

The NFCS (1999) indicated that many South African children aged 1 to 9 years old, particularly in rural areas, are food insecure and nutrient deficient (Bagriansky *et al.* 2002). Many of these children depend on foods inadequate both in quantity, nutritional density and quality. Further, the dietary intake of vitamin A among the South African children is less than 67 percent and in many cases below 50 percent of RDA of children aged 1 to 5 years old (Bagriansky *et al.* 2002, Klugman 2002).

Maize is the staple food for rural populations (NFCS 1999). One recommendation to eliminate vitamin A deficiency among the South Africans is to increase vitamin A intakes to at least 82 percent of the RDA through fortification of maize meal (Msimang 2002). Hence the current study assessed the possible contribution of fortified maize meal to the vitamin A intakes of rural households. Maize meal is the only likely source of the vitamin A fortified foods consumed by rural populations in South Africa.

6.2 Determination of average vitamin A intakes from maize porridge in rural South Africa

Many children in rural South Africa rely on maize for their nutrition with the median consumption of 500g per day for age group 7 to 9 years and 410g per day for age group 1 to 3 years old (Bagriansky *et al.* 2002, Klugman 2002) (Figure 6.5). Labadarios *et al.* (2001) have noted that many South Africans depend on purchased foodstuffs (including purchased maize) rather than on subsistence agriculture.

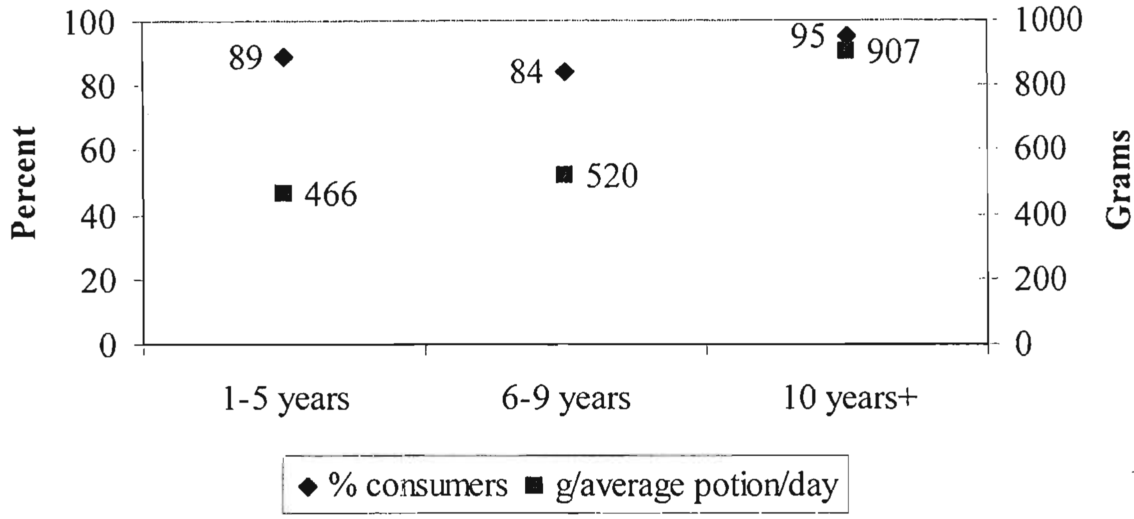

Figure 6.5 Consumption of maize porridge by rural South Africans (adapted from Nel and Steyn 2001)

A survey of maize meal was carried out in a range of supermarkets in Pietermaritzburg to determine vitamin A levels and the possible contribution of fortified maize meal to RDAs of rural households. Only maize meal fortified with vitamin A was included in the survey as there are other brands of maize meal that are not fortified. However, all maize meal has to be fortified with vitamin A from mid 2003 (de Hoop and Matji 2002). Table 6.3 presents the comparative vitamin A content of different brands of maize meal found in a sample of Pietermaritzburg stores.

Table 6.3 Maize meals enriched with vitamin A and their vitamin A content per 100g and 200g servings, rural South Africa, 2003

Brand name	Average value per 100g/RE (uncooked)	% RDA per 100g serving (uncooked)	Average value per 200g/RE (uncooked)	% RDA per 200g serving (uncooked)
	250g porridge		500g porridge (1-9 years)	
Iwisa	83	8	166	17
Ace	141	14	282	29
Impala	67	7	134	13
White Star	128	12	256	25

Source: maize meal packets. Tiger Foods Brands Ltd packs Ace while Impala while Iwisa and White star are packed by Premier Foods.

Table 6.4 presents the estimated vitamin A consumed from maize porridge (using information from Table 6.3) for different brands of maize meal and the average portion sizes of maize porridge given for age groups 1 to 5 years and 6 to 9 years (Nel and Steyn 2001).

Table 6.4 Estimated daily intake of vitamin A from maize porridge made from fortified maize meal for 1-9 year olds, rural South Africa, 2003

Brand name/ average RE and % RDA	RE/250g maize porridge	1-5 years old (average g/person/day = 466g), when RDA= 400RE		6-9 years old (average g/person/day = 520g), when RDA = 600RE	
		RE/466g	*%RDA/466g*	*RE/520g*	*%RDA/520g*
Iwisa	83	155	39	173	28.7
Ace	141	263	66	293	48.8
Impala	67	125	31	139	23.2
White star	128	239	60	266	44
Average	105	196	49	218	36

The average portion sizes of maize porridge are adapted from Nel and Steyn (2001) and %RDA is calculated based on nutrition information provided on maize meal package.

Based on the recommended vitamin A intakes of 1 to 9 year olds (that is, 400RE for 1 to 5 year olds and 600RE for 6 to 9 year olds), how much each brand of maize meal could contribute to RDA of rural South African children was estimated. Maize porridge made from *Ace* and *White Star* contributed more vitamin A to the RDAs of 1 to 9 year olds than *Iwisa* and *Impala*. Fortified maize meal contributed an average of 49 percent of vitamin A for 1 to 5 year olds and 36 percent for 6 to 9 year olds respectively.

6.3 Determination of typical vitamin A intakes of rural South Africans from non-vegetable sources

While fortification of maize is highly recommended to meet the needs of vulnerable people, its aim is not to provide 100 percent RDA of vitamin A. Thus, 100 percent of the RDA should be attained by combining vitamin A from a variety of food sources (Bagriansky *et al.* 2002). Where 1 to 9 years olds in rural South Africa consume vitamin A rich animal foods, they could obtain 25 percent of RDA and 42.5 percent of RDA from maize porridge if fortified maize meal is selected (Table 6.5). These values total to 67.5 percent of the RDA for vitamin A, resulting in a shortfall of 32.5 percent.

Table 6 .5 E stimated v itamin A consumed from protein foods and fortified maize meal for South African children 1-9 years old, 2003

	Children 1 to 5 years old	Children 6 to 9 years old
Vitamin A required (RE)	**400**	**600**
Average vitamin A consumed from animal foods (RE)	114	196
Estimated % RDA per portion of animal foods consumed	29	49
Average vitamin A consumed from fortified maize meal (RE)	112	218
Estimated % RDA per portion of fortified maize meal consumed	19	36
Average % RDA from animal foods and maize meal	**25**	**42.5**

It must be noted that households whose diets include milk, fish, eggs and fortified maize meal may attain 67 percent of RDA. It is possible that many households consume less than 67.5 percent of their vitamin A requirements due to poor food choices. **Therefore, it is assumed that at least 33 percent of RDA of vitamin A for rural households would typically come from vegetables.**

6.4 Model development

The model for determining adequacy of vitamin A and vegetable servings provided by the garden unit/s presented in Chapter 3 was designed using Microsoft Excel version 9. Each spreadsheet include estimations of the vitamin A requirements by age/gender group and by households (Appendix P), adequacy of vitamin A consumed from vegetables by 1 to 5 year olds (Appendix Q), 6 to 14 year olds (Appendix R) and adults 15 year olds and above (Appendix S) and adequacy of the potential vitamin A from the garden unit/s and adequacy of vegetables for one household (Appendix T). A total of 52 spreadsheets were designed for the sample households. The separate spreadsheet was designed to calculate total vegetable yields per garden unit and the total vitamin A provided by one garden unit (Appendix U). Data of vegetable yields and the potential vitamin A per garden unit was imported into household spreadsheets to calculate vegetable and vitamin A adequacies of each household. The summary spreadsheet captured data from all the spreadsheets designed for the sample households of three data sets defined below (Appendix V).

- The first data set was used to compare household vitamin A requirements with current vitamin A intake from vegetables.

- The second data set was used to compare vitamin A requirements with the vitamin A provided by the garden unit/s.
- The third data set compared vegetable servings provided by the garden unit/s to the vegetable servings required by each household for eight weeks, the typical cropping season.

The variables employed in the three data sets are specified in Table 6.6 to present the overall structure of the model. The vitamin A requirement was dependent on household size and composition. The vitamin A content of vegetables consumed, portion sizes of vegetables consumed by different age groups, and frequency of vegetable consumption determined the adequacy of vitamin A consumed from vegetables. The vitamin A content of vegetables produced, and the vitamin A required for each household determined the adequacy of vitamin A provided by the garden unit/s. The number of vegetable servings required by each household, and servings provided by the garden unit/s were used to establish the adequacy of vegetables for each household. This section presents the methods applied in the development of the model.

6.4.1 Vitamin A requirements per household

Demographic data from the survey presented in Chapter 4 was used to compute the vitamin A requirements for each sample household. Vitamin A requirements of household members were determined by age, gender, and whether females were pregnant or lactating (Chapter 2, Table 2.2). Children under one year old were excluded in the model since their vitamin A intake may be influenced by breastfeeding and since small children dislike vegetables. Thus, to calculate household daily vitamin A requirements,

Table 6.6 The evaluation model variables

Variables	To measure
Household composition	Vitamin A and vegetable servings required by each household based on age, gender and physiological status composition.
Household size	Current vitamin A intake, number of vegetable servings required and of servings provided by garden units for each household.
Household vitamin A requirements	Amount of vitamin A required by each household based on household composition and RDAs.
Vitamin A content of vegetables	Vitamin A present in each vegetable consumed and produced in the garden unit/s.
Portion sizes of vegetables consumed	Amount of vitamin A consumed from each vegetable commodity.
Frequency of vegetable consumption	Amount of vitamin A consumed from vegetables by household members.
Adequacy of vitamin A intake	Adequacy of vitamin A consumed from vegetables to meet the requirements of households.
Household vegetable servings required	Number of vegetables required by each household in a season.
Adequacy of vitamin A from produce	Feasibility of garden units in providing adequate vitamin A for households.
Vegetable adequacy	Adequacy of vegetables produced from garden units to meet subsistence requirements of each household.

the number of household members in age groups above one year categorised by gender and physiological status was multiplied by their respective vitamin A requirements. The sum of vitamin A requirements for each household was computed. The daily vitamin A requirements were multiplied by seven days, then by eight weeks to find weekly and seasonal requirements respectively.

6.4.2 Estimation of household vitamin A intakes

The food frequency method was used to investigate the frequency consumption of different types and varieties of vegetables per week by each household. This data came from the survey presented in Chapter 4 (refer to Appendix M, question 15). The vitamin A contents of vegetables provided in Chapter 2, table 2.7 were used to estimate the vitamin A per portion sizes of vegetables consumed by the sample households.

Although the age grouping used by Nel and Steyn (2001) differs slightly with the age grouping used here, this study used the average portion sizes of vegetables consumed per day by rural South Africans aged 1 to 5 years old, 6 to 9 years old and 10 years as shown in Table 6.7. To estimate the contribution of vegetables to the vitamin A intakes of households, the portion sizes of vegetables consumed by different age groups in each household were converted into approximate vitamin A contents.

Table 6.7 Portion sizes of vegetables consumed by different age groups in rural South Africa, 1999 (adapted from Nel and Steyn 2001)

Household composition	Portion sizes of vegetables consumed per person per day
Children 1-5	132
Children 6-14	140
Adults 15 years and above	176

This was carried out by multiplying the portion sizes of vegetables consumed (by each age group) by the vitamin A content per 100g of vegetables consumed, divided by 100g. For example, vitamin A consumed from carrots by a child aged 1 to 5 year old would be:

$$\text{Vitamin A per portion size consumed} = \frac{\text{vitamin A per 100g x portion size consumed}}{100\text{g}} \qquad (1)$$

$$\text{For example: Vitamin A per132g of carrots} = \frac{1250\text{RE x }132\text{g}}{100\text{g}} = 1650\text{RE}$$

The vitamin A content of each vegetable consumed was then multiplied by the frequency of consumption per week. For instance, if carrots were included two times per week in the family diet, a child aged 1 to 5 years obtained 3300RE from carrots per week. Then, vitamin A consumed from carrots over a week was divided by seven days to find an average vitamin A consumed per day since consumption of vegetables varies over time. Thus, a child aged 1 to 5 years old from a selected household obtained an average of 471RE per day as shown below.

$$\text{Daily vitamin A consumed per person} = \frac{(\text{vitamin A per portion size x frequency per week})}{7\text{ days}} \qquad (2)$$

$$\text{E.g. daily vitamin A from carrots per child 1-5 year old} = \frac{1650\text{RE x }2}{7\text{ days}} = 471\text{RE}$$

The average daily vitamin A intake from each vegetable consumed (by each age group) was multiplied by the number of people per age group to find the total vitamin A consumed by age groups per household. This implies that if there were two children aged 1 to 5 years old from a selected household, the total vitamin A from carrots for these children would be 943RE per day as shown below.

Daily vitamin A consumed per age group = average daily vitamin A per vegetable x people per age group (3)

E.g. vitamin A consumed from carrots per 1-5 year olds = 471RE x 2 preschoolers
= 943RE

The average daily vitamin A provided by each vegetable consumed (by each age group) was divided by the RDA for vitamin A multiplied by 100 for the respective age group to calculate the proportion of vitamin A each vegetable contributed to the RDAs of different age groups (Equation 4). This procedure was applied to all vegetables consumed and to all age groups present in each household to estimate the average vitamin A consumed from vegetables per day by households.

For example, each child aged 1 to 5 year old requires 400RE per day. Two children aged 1 to 5 years old would require 800RE per day. In a selected household, two children aged 1 to 5 years would obtain the daily average of 943RE from carrots consumed two times per week, 5RE from chinese cabbage if consumed once per week and 290RE from tomato if consumed seven times per week. Based on the vitamin A requirements of this age group, carrots would provide 118 percent, chinese cabbage would provide one percent and tomato would provide 36 percent to the RDA of 1 to 5 year olds as shown below.

Vitamin A adequacy per vegetable per age group = average (daily vitamin A consumed per vegetable) x 100 ÷ RDA per age group. (4)

E.g. Adequacy of vitamin A from carrots per 1-5 year olds = (943RE ÷ 800RE) x 100
= 118

Adequacy of vitamin A from chinese cabbage per 1-5 year olds = (5RE ÷ 800RE) x 100
= 1

Adequacy of vitamin A from tomato per 1-5 year olds = (290RE ÷ 800RE) x 100
= 36

To assess whether vitamin A consumed from vegetables was adequate, the proportions each vegetable (included in the model) contributed to the vitamin A requirements of each age group were averaged. Therefore, 1 to 5 year olds from a household given above consumed 12 percent of RDA of vitamin A from vegetables (Equation 5).

Vitamin A adequacy/age group = average (adequacies of vitamin A of all vegetables) (5)

E.g. vitamin A adequacy per 1-5 year olds = average (118, 1, 36, 0.....0) = 12.

Whether vitamin A consumed by each household was adequate to meet the household vitamin A requirements was computed by summing vitamin A adequacies of all age groups present in each household. If in a selected household, children aged 1 to 5 year old consumed 12 percent of their RDA from vegetables, 6 to 14 year olds consumed eight percent of their RDA and adults above 15 year old consumed 10 percent of their RDA, the average percent of RDA for that household would be 10 percent. An adequacy value greater than 100 percent indicates that vitamin A intake is more than the required levels, while the value less than 100 percent vitamin A intake below the required levels.

6.4.3 Vitamin A adequacy of the garden unit/s per household

A trial garden unit was designed to contribute a significant share of vitamin A to household requirements. Therefore, the potential of the garden unit to meet the vitamin A requirements of households was estimated. Vitamin A provided by the garden unit was computed by first converting the potential vegetable yields into potential vitamin A provided. To estimate the potential yield per garden unit, quantities of different types of vegetables recommended for the garden unit were multiplied by their respective average weights. Then the vitamin A content of each vegetable per 100g was multiplied by individual vegetable yield per garden unit and the sum was computed to find vitamin A per garden unit as illustrated in Equation 6 below.

Vitamin A per garden unit =Sum (yield per vegetable x vitamin A per 100g per vegetable produced
(6)

The vitamin A produced by the garden unit will differ with the types of vegetables grown in an eight-week period (cropping season). The gardening season was estimated to be eight weeks since the average harvesting period of most vegetables that could be produced in the garden unit is eight weeks. However, if the planting times are consistent with the seasonal calendar (Appendix E), sample households can have at least eight varieties of vitamin A rich vegetables available throughout the year. Carrots and Broccoli could be available for at least 10 months in a year. Other vegetables included in the garden unit such as garlic, leeks and onion are seasonal, but they serve as crop repellent crops rather than vitamin A sources.

A trial garden unit could produce 71043RE per season (Appendix U). Vitamin A provided by one garden unit was multiplied by the number of garden units each household had to estimate the total vitamin A produced for each household. The total vitamin A produced from the garden unit/s was divided by the seasonal vitamin A requirements of a selected household multiplied by 100 to establish the potential vitamin A adequacy of the garden unit/s (Equation 7). A value greater than 100 percent indicates that the garden unit/s provides surplus of vitamin A for sample households and the value below 100 percent indicates that vitamin A provided by the garden unit/s is less than the RDAs of households.

A household of 11 people requires 11 garden units. To compute the total vitamin A from produce, vitamin A per garden unit was multiplied by 11 garden units. If the selected household requires 6400RE per day, the seasonal vitamin A requirements would be 3585400RE (i.e. 6400RE x 7 days x 8 weeks). The percentage RDA for vitamin A from the garden units would be 218, indicating a surplus of 118 percent for that household (Equation 7). The estimated proportion of vitamin A from the produce is based on vegetables included in the garden unit.

$$\text{Adequacy of vitamin A of produce} = \frac{(\text{vitamin A per garden unit x number of garden units}) \times 100}{\text{Seasonal household vitamin A requirements}} \quad (7)$$

$$\text{E.g. adequacy of vitamin A of produce} = \frac{(\text{71043RE x 11 people}) \times 100}{\text{358400RE}} = 218$$

6.4.4 Vegetables adequacy of the garden unit/s per household

Vegetable servings provided by the garden unit/s relate to production necessary to ensure adequate supply of vegetable servings required by households. Vegetable servings required by each household per day were computed by multiplying the number of people in each age/gender group by the number of vegetable servings recommended for respective age groups (Equation 8). Basiotis *et al.* (2000) and Seals (undated) recommendations of vegetable servings per day were used to compute the vegetables servings required by each household (Table 6.9). A household comprising of two children aged 1 to 5 years old, three children aged 6 to 14 years old, four females aged 15 years and above and two males aged 15 years and above require 43 vegetable servings per day.

Table 6.9 The recommended daily vegetable servings by gender/age group (Basiotis *et al.* 2000, Seals (undated)

Household composition	vegetable servings recommended per day
Child 1-5	3
Child 6-14	4
Females 15 and above	4
Males 15 and above	5

Daily vegetable servings required per age group = vegetable servings required per person per age group x people per age group (8)

E.g. vegetable servings required per males <15 years old = 5 vegetable servings x 2 males
= 10 vegetable servings

The vegetable servings required per day by each age group were summed to estimate the daily servings required per household. The daily vegetable servings required by households were multiplied by seven days to measure the requirements per week. To calculate the seasonal vegetable servings required by households, weekly servings were multiplied by eight weeks. Therefore, a household that requires 43 vegetable servings per day would require 303 servings per week and 2424 servings per season.

The trial garden unit's estimated production was 16745g of vegetables (Appendix U). The amount produced will differ with the types of vegetables grown in the prevailing season. The potential vegetable yield per garden unit was multiplied by the number of garden units for individual households to estimate the total yield produced. To estimate the total number of servings produced per household, the yield from garden unit/s was divided by 80g, which is recommended as the portion size of one serving per person (Seals undated). The vegetable servings produced were compared to the servings required by each household to calculate vegetable adequacy (Equation 9). The potential yield of vegetables for a household that has 11 garden units is 184195g (16745g x 11 garden units).

$$\text{Vegetable servings produced} = \frac{\text{vegetable yield per total produce per household}}{80\text{g}} \quad (9)$$

$$\text{E.g. vegetable servings produced for household of 11 people} = \frac{184195\text{g}}{80\text{g}} = 2302 \text{ servings}$$

The number of servings required by each household was multiplied by the average weight of one recommended serving to estimate the amount of vegetables required by each age/gender group. The total amount of vegetables required by each household per day was multiplied by seven days and then eight weeks to find weekly and seasonal vegetable requirements respectively. When the potential yields of the garden unit/s for each household were divided by the vegetables required, the adequacy was similar to that computed for the adequacy of vegetable servings.

The equations provided in this Chapter were employed in the spreadsheets designed for each household. The summary spreadsheet, which captured data from all households, was exported into SPSS 11.0 for analysis. Histograms showing normal distribution curves were drawn for household vitamin A requirements, adequacy of vitamin A consumed from vegetables by households, adequacy of vitamin A consumed from vegetables by 1 to 5 year olds, adequacy of vitamin A consumed from vegetables by 6 to 14 year olds, adequacy of vitamin A consumed from vegetables by adults above 15 years old, adequacy of the potential vitamin A of the garden unit/s, vegetable servings required by households and adequacy of vegetables from the garden unit/s. The findings of the model results are presented in Chapter 7.

6.5 Summary

To determine adequacy of the potential vitamin A of the trial garden unit (designed in Chapter 4), an evaluation model was designed in Microsoft Excel version 9. The model analysed current vitamin A intakes of sample households to test whether the garden unit could increase the vitamin A intake of sample households. The contributions of vitamin A rich animal foods and fortified maize meal were used to determine the vitamin A that should come from vegetables.

Vitamin A rich animal foods (eggs, fish, beef offal and milk) consumed by South African rural households were identified from Nel and Steyn (2001). Portion sizes and the vitamin A content of animal foods were used to calculate vitamin A consumed from these foods. South African rural consumers obtain an average of 25 percent of the RDA from vitamin A of eggs, milk and fish.

Maize is the only likely source of vitamin A fortified foods typically consumed by South African rural households. A survey of fortified maize meal in Pietermaritzburg indicated that households who consume fortified maize meal obtain an average of 42 percent of the RDA for vitamin A from maize. Together vitamin A rich animal foods and fortified maize could contribute 67 percent of the RDA for vitamin A to the intakes of consumers. At least 33 percent of RDA of vitamin A would therefore come from vegetables. Equations were used to establish household vitamin A requirements, adequacy vitamin A consumed from vegetables, adequacy of the potential vitamin A from the trial garden unit, vegetable requirements and adequacy of vegetables provided by the garden unit.

CHAPTER 7

VITAMIN A AND VEGETABLE ADEQUACY OF THE GARDEN UNIT

Household vitamin A requirements were compared to the vitamin A consumed from vegetables by sample households to investigate whether households consumed significant levels of vitamin A from vegetables. Household vitamin A requirements were further compared to the potential vitamin A provided by the garden unit/s to find out whether households can obtain at least 33 percent of the RDA for vitamin A from the produce in the garden unit. The vegetable servings required by households were compared to the servings from the garden unit/s to establish the potential contribution of the garden unit produce to the household subsistence needs. This Chapter presents and discusses the findings of the model presented in Chapter 6.

7.1 Daily vitamin A requirements of sample households

Vitamin A requirements were assessed for households comprising of 2 to 31 household members. The results showed that total vitamin A required by sample households per day ranged from 1200RE to 18000RE (Figure 7.1). Two-thirds of sample households required vitamin A ranging between 1865RE and 8623RE. The mean vitamin A requirement of sample households was 5244RE. However, the outliers of 10000RE to 18000RE, which resulted from extreme household sizes of 30 and 31 people could have influenced the mean. Therefore, the median was used as the central measure (± 4200RE).

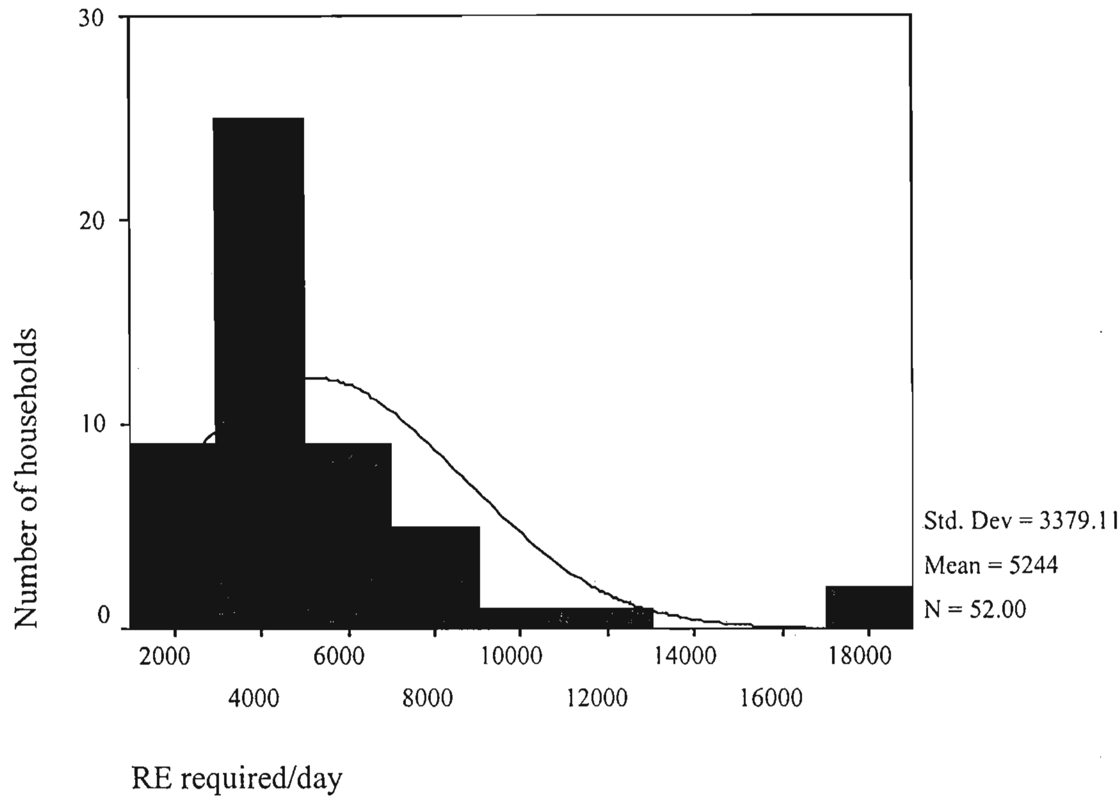

Figure 7.1 The daily vitamin A requirements of sample households, Cuphulaka and Mlwandle, 2003, (n=52)

Vitamin A requirements of households were more dependent on household composition than household size. When the number of household members in an age or physiological status category that requires large amounts of vitamin A increased (as for pregnant and lactating women), the vitamin A required for that household increased significantly.

7.2 Adequacy of vitamin A currently consumed from vegetables by sample households

In the process of simulating the potential vitamin A adequacy of the garden unit/s among sample households, the study established that South African rural households that consume vitamin A rich animal foods and fortified maize meal are likely to obtain an average of 67 percent of RDA of vitamin A from these foods. The study calculated that South African rural households should consume at least 33 percent of RDA of vitamin A from vegetables and assumed that all households consumed fortified maize, which may not have been the case, but new legislation of fortification of all maize meal will influence this.

This section evaluates the current contribution of vegetables to the total vitamin A requirements of sample households. The study assessed vitamin A intakes of sample households to determine whether household members currently consume 33 percent of their total vitamin A requirements from selected vegetables. This was established by measuring the frequency consumption of vitamin A rich vegetables. The vitamin A consumed from vegetables was assessed for each household and by age groups of 1 to 5 year olds, 6 to 14 year olds and those over 15 years.

The results indicate that vitamin A consumed from vegetables by sample households ranged from zero to 2977RE per day. Although sample households required an average of 5 244RE of vitamin A per day, vitamin A consumed from vegetables averaged only 1109RE (21 percent of the total household requirements for vitamin A). Fifty percent of households consumed below 895RE, which is less than 20 percent of their recommended vitamin A intakes, and 90 percent of sample households consumed less than 33 percent, which the study assumed should come from vegetables (Figure 7.2).

About two-thirds of the study sample consumed between 3 and 35 percent of their daily vitamin A requirements with most households consuming vitamin A from vegetables close to the sample consumption mean of 19 percent of total vitamin A requirements.

Seventy-five percent of sample households consumed vitamin A below 33 percent of their total requirements for vitamin A. The three percent of households that consumed more than half their total vitamin A requirements consumed less than 61 percent of RDA for vitamin A.

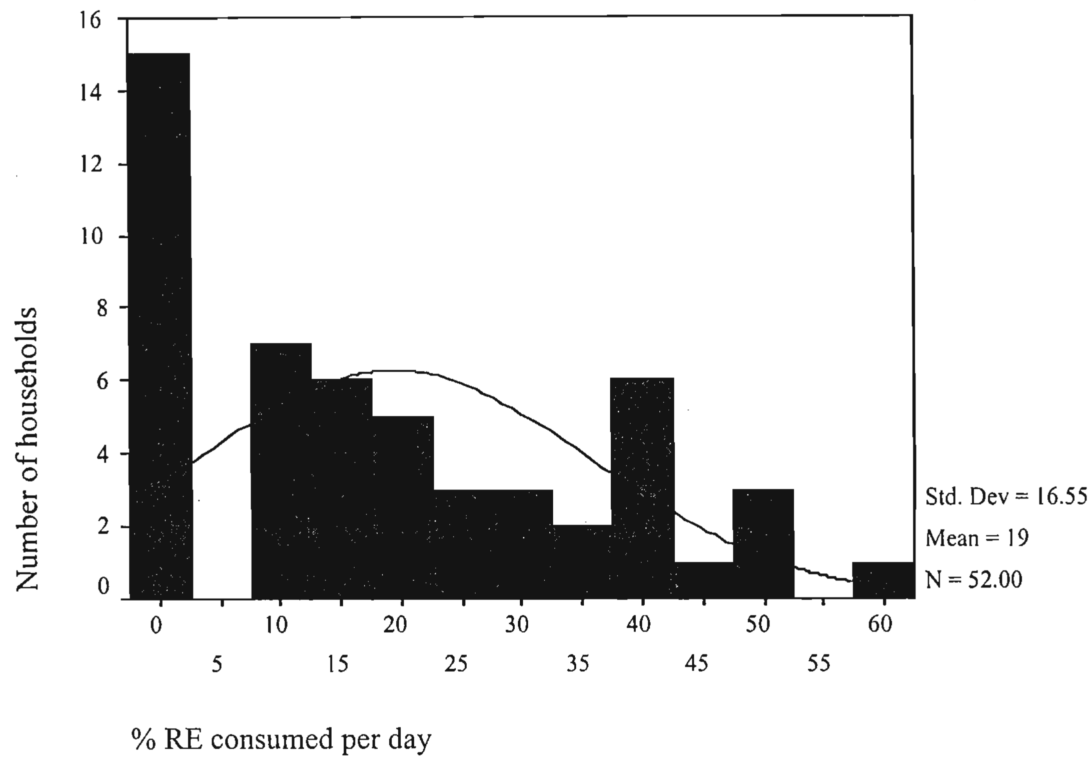

Figure 7.2 Adequacy of vitamin A consumed from vegetables by sample households, Cuphulaka and Mlwandle, 2003 (n=52)

Household members of different age groups in study areas consumed less vitamin A from vegetables than their requirements. Ninety-five percent of children aged 1 to 5 years, all children aged 6 to 14 years, and 95 percent of those aged 15 years and above, consumed less than 50 percent of the total RDA for vitamin A. Children aged 1 to 5 years consumed proportionately more vitamin A than that consumed by children aged 6 to14 years old (Figures 7.3 and 7.4). Two-thirds of households with children aged 1 to 5 years reported vitamin A intakes equivalent to 4 to 38 percent of the total requirements of this age group, with 75 percent of these households reporting vitamin A intakes less than 33 percent of RDA among 1 to 5 year olds.

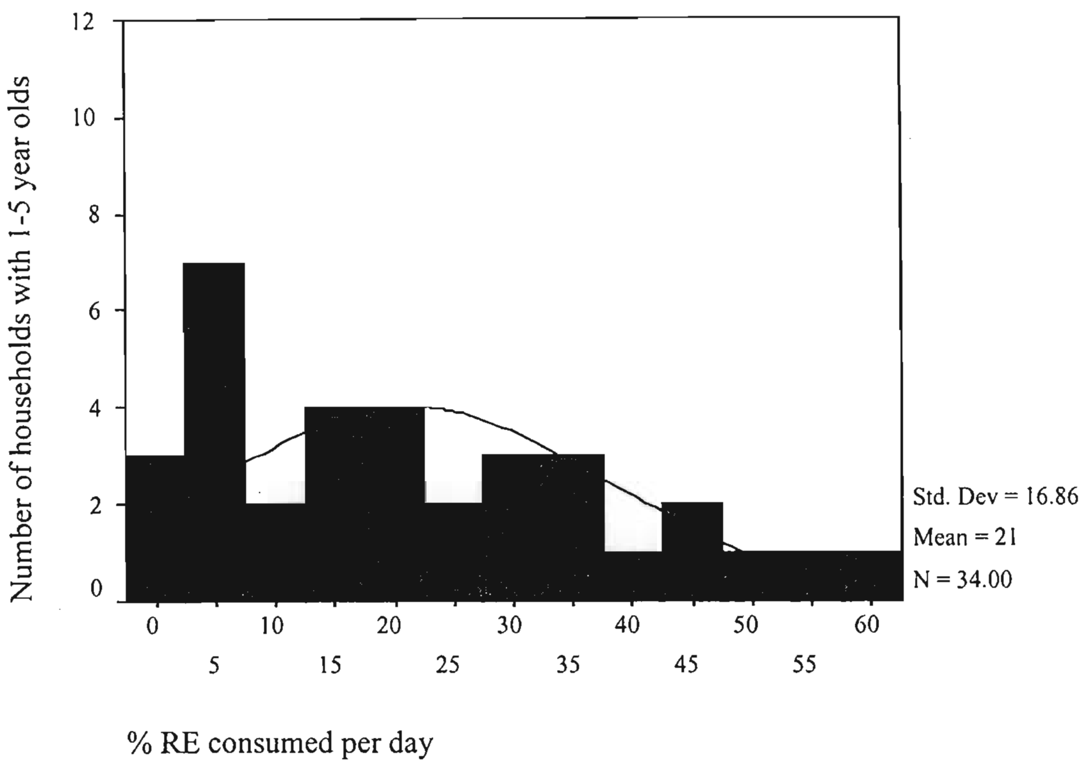

Figure 7.3 Adequacy of vitamin A consumed by children aged 1 to 5 year old, Cuphulaka and Mlwandle, 2003 (n=34)

Of households with children aged 6 to 14 years old, 66 percent reported vitamin A intake between 3 and 29 percent of the requirements of this age group. Eighty-five percent of these households reported vitamin A intakes less than 33 percent among 6 to 14 year olds. Sixty-percent of sample households reported that adults consume vitamin A between 3 and 37 percent of their recommended intakes, with 75 percent of these households reporting vitamin A intakes less than 33 percent of the total vitamin A requirements (Figure 7.5). These figures indicate that many sample households consumed vitamin A rich vegetables less frequently, resulting in vitamin A intakes below 33 percent of the RDA of vitamin A that the study assumed should come from vegetables.

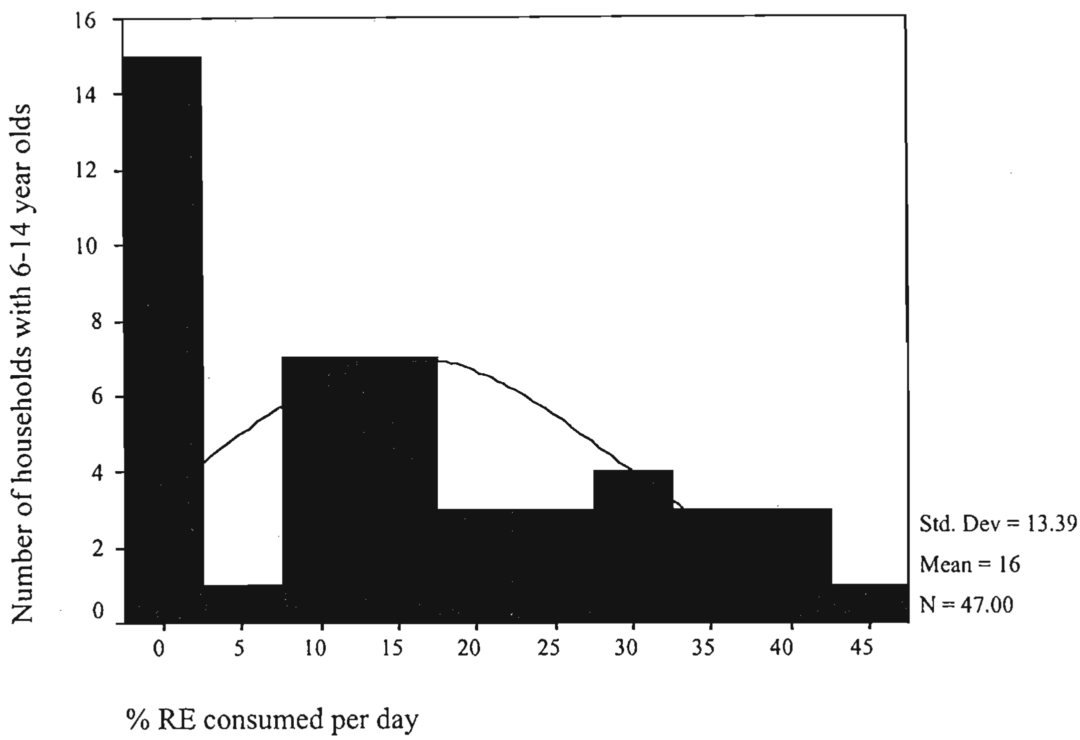

Figure 7.4 Adequacy of vitamin A consumed by children aged 6 to 14 year old, Cuphulaka and Mlwandle, 2003 (n=47)

The findings indicate that 51 percent of the sample households consumed less than 16 percent of their vitamin A requirements from vegetables. Therefore, vitamin A intakes of many sample households (including households that consume vitamin A rich animal foods and fortified maize meal), remain low since many households still consume less than the minimum 33 percent of the vitamin A RDA from vegetables. This implies that households who depend more on plant foods for vitamin A, ought to eat more carotene-rich fruits and vegetables. If carotene-rich fruits and vegetables are selected, it is still possible to obtain the RDA of vitamin A since only half a cup of cooked carrots can satisfy the daily recommended vitamin A for adults (Barr and Thirsk 2001).

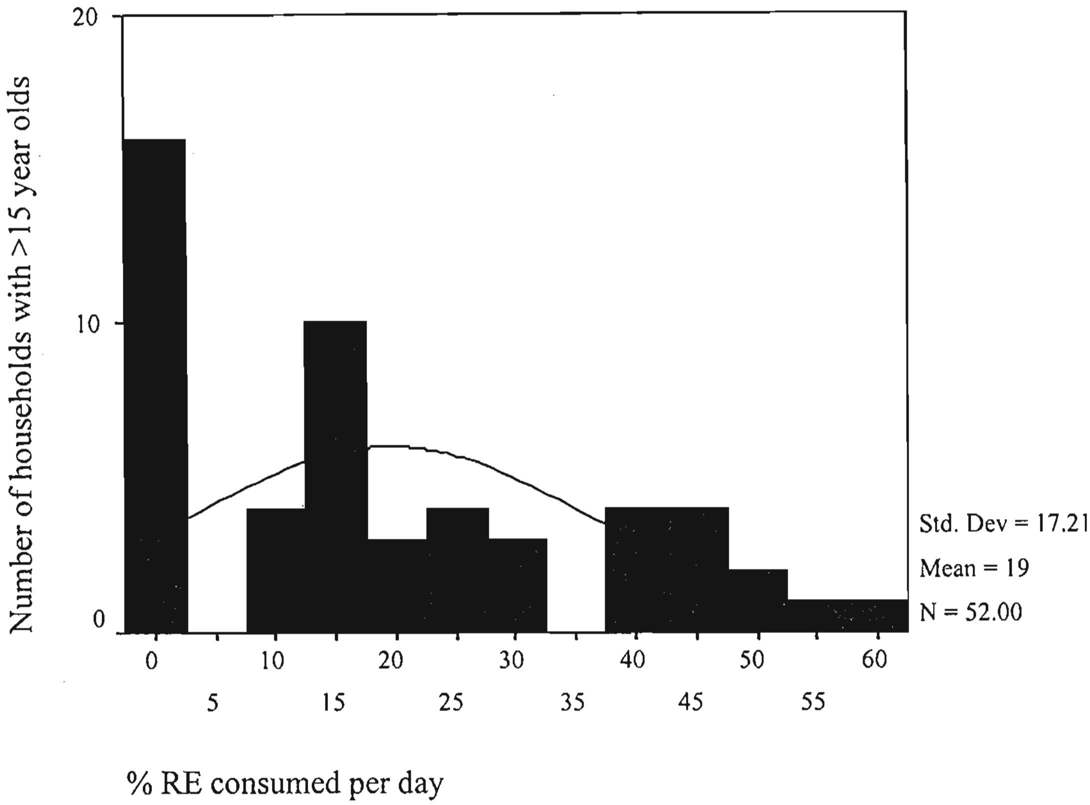

Figure 7.5 Adequacy of vitamin A consumed by adults 15 year old and above, Cuphulaka and Mlwandle, 2003 (n=52)

The findings of this study compare favourably to the South African NFCS (1999) findings, which indicated that vitamin A intakes in many South African rural households were less than 67 percent of the recommended dietary allowance for vitamin A, and in many cases, below 50 percent of the RDAs. Between 62 and 70 percent of children in rural areas and between 48 and 62 percent of children in urban areas consumed less than half of their recommended vitamin A (Labadarios *et al.* 2001).

The South African NFCS (1999) revealed that children aged 1 to 9 years old typically consume maize, sugar, tea, whole milk, brown bread and margarine, indicating low intakes of vitamin A rich foods (Labadarois *et al.* 2001). Vegetables were not frequently consumed by South Africans (Love and Sayed 2001). Low intakes of vitamin A in Cuphulaka and Mlwandle may be explained by the fact that data was collected in April when many households were still planting winter vegetables in their gardens, but had little produce available. This could imply that during this month, households consumed vitamin A rich vegetables less frequently and the data may not necessarily be representative of annual consumption. However, according to the garden unit planting guide (Appendix D), sample households could have vegetables all year round.

Although sample households participated in vegetable communal gardens, their consumption of vitamin A rich vegetables was low. The most frequently consumed vegetables were onions and tomato, which have no or little vitamin A. Given that there is little variation of vitamin A intakes between sample households who depend mainly on communal gardens and who depend also on household food gardens, low intakes of vitamin A rich vegetables may be a result of poor eating habits and lack of dietary diversity. Low production of vitamin A rich vegetables due to reported lack of water and fencing materials also contribute to poor consumption of these vegetables.

7.3 Adequacy of vitamin A from the garden unit/s among sample households

The garden unit aimed to provide households with a significant supply of year-round vitamin A rich vegetables. This section assesses the potential contribution of the garden unit/s to the vitamin A requirements of the sample households. The findings of the model demonstrate that at least 68 percent of the sample households can obtain a surplus of 86 to 135 percent of RDA of vitamin A of total household vitamin A requirements from the garden unit/s. The adequacy of vitamin A supply from the garden unit/s (Equation 7) indicates that many households in study areas can obtain vitamin A close to 210 percent of their RDAs (which is more than 33 percent RDA of vitamin A) (Figure 7.6).

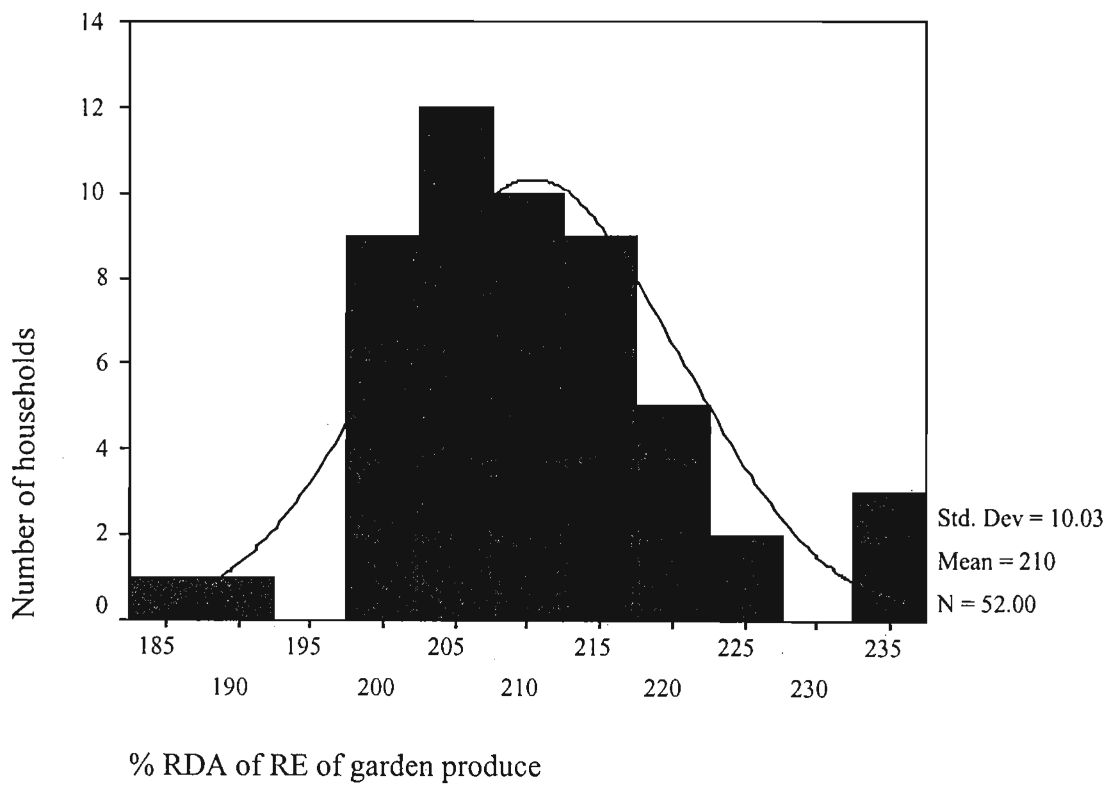

Figure 7.6 Adequacy of vitamin A from the garden unit/s, Cuphulaka and Mlwandle, 2003, (n=52)

7.4 Adequacy of vegetable servings from the garden unit/s among sample households

The potential vegetable yield was compared to the vegetable requirements of sample households to establish whether the garden unit/s can meet the vegetable consumption requirements of these households. The quantity of vegetables required and produced from the garden unit/s was converted into vegetable servings in order to assess if the demand for vegetables balanced with supply.

Vegetable servings required for eight weeks by sample households (Equation 8) ranged from 448 to 7129. About two-thirds of sample households required 699 to 3255 vegetable servings per season (Figure 7.7). Fifty percent of households required less than 1614 vegetable servings, while the mean requirement was 1976 vegetable servings. When the production of vegetables from the garden unit/s was compared to the vegetable servings required by each household, the results showed that the garden unit/s can potentially contribute 87 to 97 percent of vegetable requirements of the majority of households in study areas (Figure 7.8).

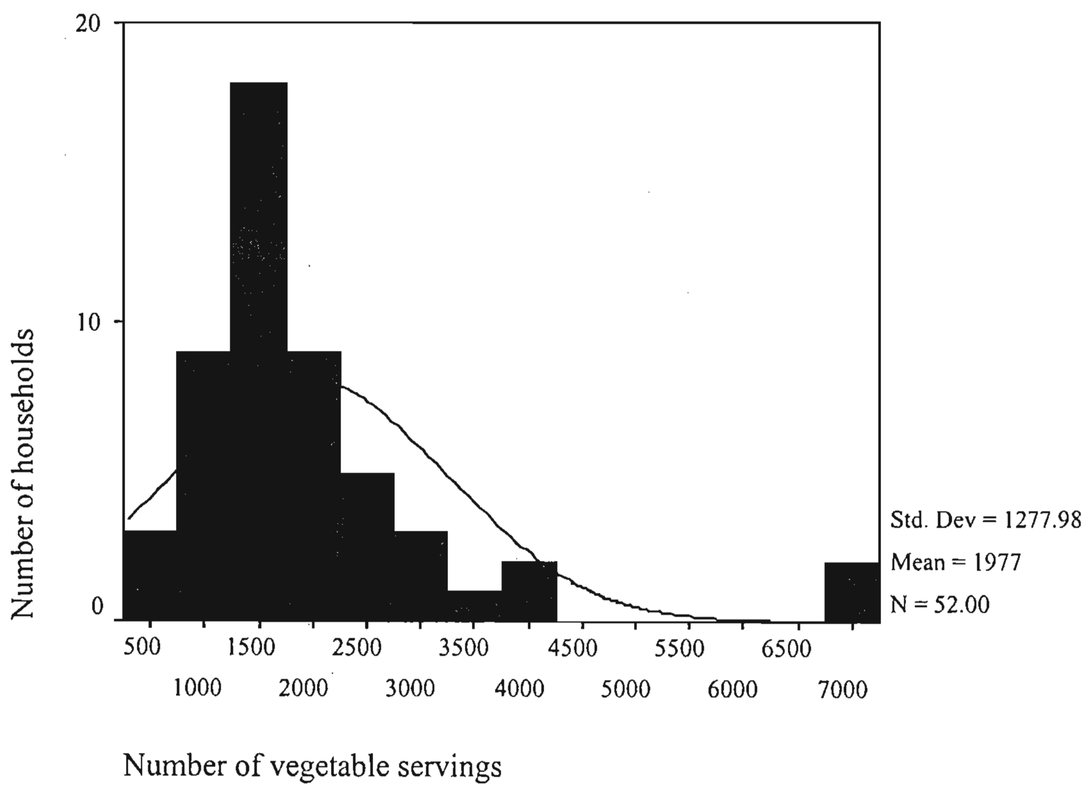

Figure 7.7 Vegetable servings required by sample households per season, Cuphulaka and Mlwandle, 2003, (n=52)

The actual vegetable servings consumed by households were not measured. Thus, the study has not established the relationship between vegetables consumed and the potential vegetable yields from the garden unit/s. However, sample households do not meet the 3 to 5 vegetable servings recommended per day. This NFCS (1999) also indicated that the majority of South Africans do not consume the five portions of vegetables recommended per day (Love and Sayed 2001).

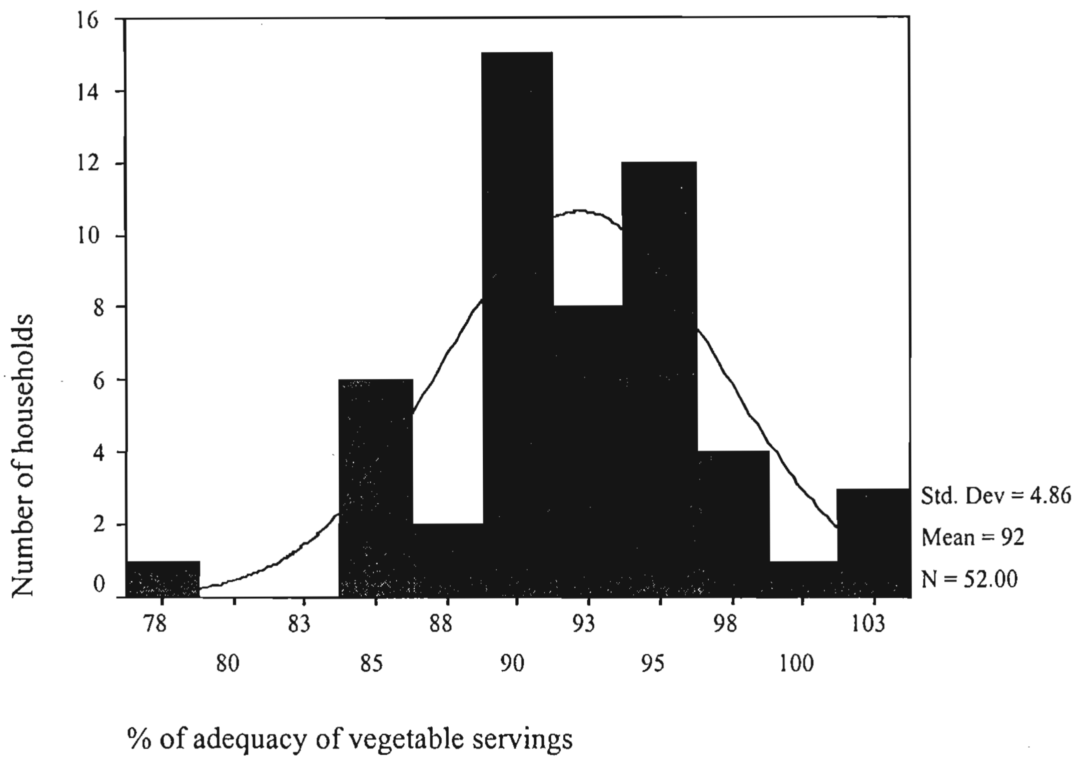

Figure 7.8 Adequacy of vegetables from the garden unit/s among sample households, Cuphulaka and Mlwandle, 2003, (n=52)

The trial garden model has indicated the potential to provide households with significant vitamin A contribution and enough vegetables to meet the vitamin A requirements if fortified maize and some vitamin A rich animal foods are consumed. Since the sample households accepted the garden unit and found it feasible, production of vitamin A rich vegetables could increase significantly if extension services can provide guidance of how to produce and prepare vegetables that sample households are not familiar with.

The studies reviewed in Chapter 2 indicated that many garden projects in developing countries that integrated nutrition education, community participation, demonstrations, printed materials and public addresses were more successful in increasing production and consumption of vegetables for households, and therefore successful in improving the vitamin A status of household members (Marsh 1998, Callens and Phiri 1998, English and Badcock 1998, Faber and Benadé undated).

7.5 Summary

Household vitamin A requirements were influenced more by the number of people in an age or physiological status category that needs high vitamin A (such as pregnant and lactating women) than by total household size. Households in study areas consumed little vitamin A from vegetables compared to their requirements. This may be due to inadequate and seasonal production of vegetables. Despite the fact that sample households participated in communal vegetable gardens, their intake of vitamin A remained below the recommended levels. The most commonly consumed vegetables were onion and tomato, which have no or little vitamin A.

The garden unit could provide significant amounts of vitamin A (above 33 percent of the RDA) established as the minimum intake from vegetables. The garden unit has shown potential to increase vitamin A availability and the vegetable security of many sample households. As South African rural households typically consume diets low in vitamin

A, development planners should establish strategies that encourage production and consumption of vitamin A rich vegetables in food gardens. Since the garden unit was accepted and found feasible by the sample households, vitamin A intakes of households in study areas could be improved through implementation of the garden unit/s.

CHAPTER 8

CONCLUSIONS AND RECOMMENDATIONS

The study set out to develop a trial model of a sustainable household food garden to ensure adequate supply of vitamin A rich vegetables to meet the vitamin A and vegetable requirements of low-income households throughout the year and to investigate households' perceptions of the feasibility and acceptance of the garden unit. The study developed an organic household garden unit to provide adequate vitamin A rich vegetables for household members in rural areas. The household garden unit was demonstrated among the sample household representatives in Cuphulaka and Mlwandle to test household perceptions of the garden. The study tested vitamin A and vegetable adequacy of the garden units for the sample households.

The types of vegetables grown in home gardens were assessed to determine whether households currently produce vitamin A rich vegetables on the available land and whether home gardeners apply organic methods. The socio-economic and environmental factors that limit production of vegetables in home gardens were assessed in terms of the extent of the role they play in vegetable production. Household composition and sizes were used to compute household vitamin A and vegetable requirements and adequacies. The frequency of consumption of vegetables assessed the number of times vitamin A rich vegetables are included in diets of the sample households. The perceptions of sample households measured the feasibility and acceptance of the garden unit.

8.1 Study conclusions and recommendations

Although vegetable gardening is perceived as a cost-effective measure of diversifying and adding nutrients to family diets, home gardening among sample households was characterised by low yields and seasonal availability, resulting in low consumption of vitamin A rich vegetables. The majority of sample households utilise communal vegetable gardens rather than home gardens and sometimes depend on purchased vegetables, yet there seems to be enough land to produce vegetables in home gardens. Water scarcity and lack of fencing materials are the main constraints to home gardening amongst sample households. Availability of chicken or animal manure as nitrogen sources suggested for vegetable production may be a problem amongst sample households, as chicken and animal manure availability depends on availability of chicken or animal farmers. In the absence of green manure and lack or shortage of animal manure, the study recommends that home gardeners who are not aiming at income generation from certified organic production may use an inorganic nitrogen source.

The study estimated that South African rural consumers may obtain 25 percent of vitamin A of RDA from animal products (eggs, milk and fish) and 42 percent of RDA where fortified maize is consumed. Therefore, the study assumed that households should consume at least 33 percent of RDA of vitamin A from vegetables, yet many sample households consumed less than this. Consumption of variety of vegetables remained low even among households that obtained vegetables from both the communal and home gardens, and no significant relationship was found between vegetable production and vegetable consumption. Vegetables that were widely consumed among households were tomato and onion, which have low or no vitamin A.

The potential of the garden unit in providing substantial amounts of vitamin A and vegetables to the intakes of sample households was found adequate. The sample households accepted the garden unit and found it feasible to increase production of vitamin A rich vegetables in home gardens. Although some vegetables selected for the garden unit were neither produced nor consumed by sample households, the respondents reported that if the extension agents provided guidance of how to produce and prepare these vegetables, households could be willing to grow them in their gardens. Home-based vegetable production should be supported by extension agents to increase household vegetable supply and assist in production of vegetables the sample households were not familiar with growing.

Home gardening serves as a feasible food-based strategy to eliminate vitamin A deficiency. However, vitamin A deficiency must be controlled through a combination of strategies such as vitamin A supplementation, food fortification, genetic modification and dietary diversification. Given the low vitamin A intakes of sample households, the study recommends that rural households should increase production and consumption of vitamin A rich vegetables and foods from other food groups including fortified maize meal.

8.2 Recommendations for improvement of the study and future adoption by extension agents

The food frequency method has not provided adequate information on vitamin A intake since the study did not measure the amounts of vegetables consumed by household members. Thus, instead of using secondary information of the portion sizes of vegetables consumed by household members, a study could be carried out to measure the actual potion sizes of vegetables consumed to improve estimates in the model. This assessment could be carried out in both plentiful and lean seasons to observe variations between vitamin A intakes of households. The model could also be modified to include other micronutrients such as iron. The potential of the garden unit to provide households with iron and other micronutrients could also be simulated.

If the model was to be adopted, agricultural extension strategy may include home-based food production units. This may be done through the use of demonstration units where individual households import the skills to their home gardens to implement. Furthermore, communal gardens may be used as demonstration units. Since sample households indicated a strong desire to produce vegetables at home and for income generation beyond meeting their vitamin A and vegetable requirements, organic production with a view of future certification may be incorporated in the adoption strategy. Extension and interventions may assist 75 percent of households not practicing home gardening to be able to start. These may involve assistance with seeds and basic gardening implements. The study findings also indicated that sample households lack the skills with regard to organic production methods especially the management of pest and disease control. Training on home gardening with a view of future certified organic farming for both the farmers and extension officers who will impart these skills to the farmers is recommended.

8.3 Implications for further research

More research could be conducted following this study. An investigation of the practical potential of the garden unit is required to find out whether the garden unit could increase production of vitamin A rich vegetables in rural areas. Another important area of research is assessment of the eating patterns of households in study areas to establish factors that lead to low consumption of vegetables by households. The households' perceptions of the role of vegetables in health also need to be investigated. There is a need to investigate why the 75 percent of sample households are not currently practicing home gardening since land seems not to be a major problem. Some of the vegetables included in the study are not commonly planted and consumed by rural communities in South Africa. A model that includes more familiar vegetables such as wild spinach and other traditional foods may be investigated.

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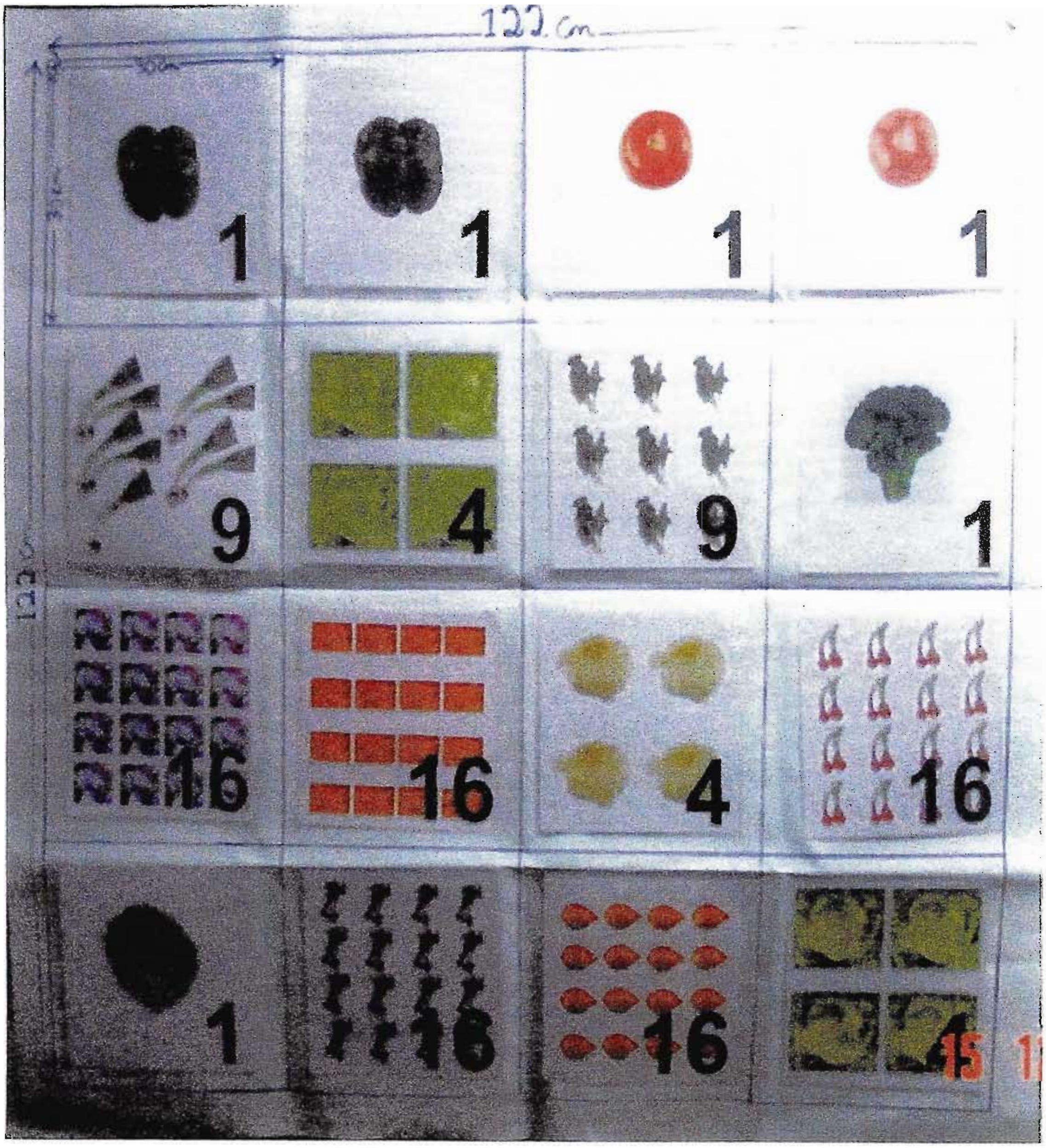
Appendix A: A diagrammatic representation of the garden unit to supply one household member



Note: numbers in squares equal the number of plants per square per vegetable variety

Appendix B: Labels of the diagrammatic representation of the garden unit to supply one household member shown in Appendix A

122cm (width); 122cm (height); each square 30cm × 30cm

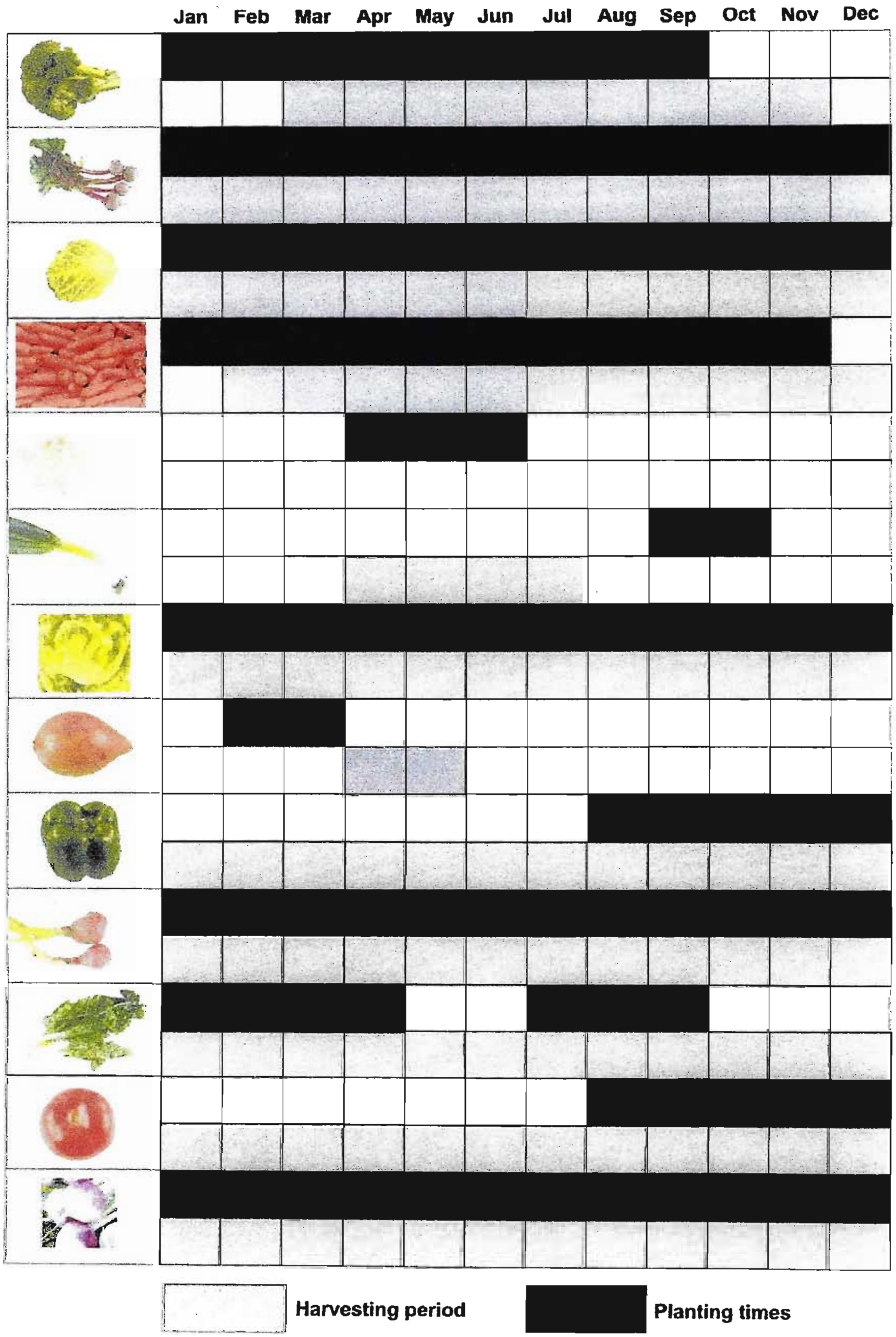
1 Pepper	1 Pepper	1 Tomato	1 Tomato
9 Leeks	4 Lettuce	9 Swiss chards	1 Broccoli
16 Radishes	16 Carrots	4 Garlic	16 Turnips
1 Chinese cabbage	16 Beets	16 Onions	4 Lettuce

Appendix C: Garden tools

Appendix D: A guide for planting and harvesting times of vegetables grown in the garden (after Young and Allemann 2002, Gilbert and Hadfield 1987).

Vegetables	Best planting times			Maturity period	Harvesting period
	Cold areas (moderate frosts)	Warm areas (light frosts)	Hot areas (frosts free)		
Beets	Aug-Mar	All year	Feb-Sept	5-8 weeks	3-5 weeks
Broccoli	Sept-Jan	Jan-Sept	Feb-Jun/July	5-9 weeks	Heads 1-2 weeks Sprouts 3-4 weeks longer
Carrots	Aug-Mar	Jan-Nov	Feb-Sept	9-16 weeks	1-4 weeks
Chinese cabbage	Sept-Feb	All year	Jan-Sept	8-12 weeks	1-4 weeks
Garlic	Apr-May	Apr-May	Apr-May	-	-
Leek	Nov-Apr	Sept-Oct	Mar-Apr	20 weeks	4-8 weeks
Lettuce	Jan-Apr, Jul-Dec	All year	Feb-Aug/Sept	5-9 weeks	1-2 weeks
Onion	Feb-Mar	Feb-Mar	Feb-Mar	4-8 weeks	1-4 weeks
Peppers	Aug-Oct	Aug-Dec	Jul-Oct/ Jan-Apr	12 weeks	8-12 weeks
Radish	Jul-Apr	All year	Mar-Oct	3-5 weeks	1-2 weeks
Swiss chard	Aug-Feb	Jan-Apr/Jul-Sept	Feb-Aug	7-8 weeks	8-12 weeks
Tomato	Sept-Nov	Aug-Dec	Dec-Mar/ Jul-Sept	6-8 weeks	4-12 weeks
Turnips	Aug-Mar	All year	Feb-Sept/ Oct	8-10 weeks	3-5 weeks

Appendix E: Vegetable seasonal calendar for warm areas



Appendix F: How to apply green and animal manure (Lindgren *et al* 1990, Boyhan *et al* 1999).

Green manure

1. Grow plants such as the legumes in the garden to be cultivated to vegetables.

2. Turn these fresh plants into the soil to increase organic matter.

3. Then grow vegetables in the garden.

Animal manure

1. Dry fresh animal manure in the shade and store it for later use.

2. Fresh animal manure burns plants if planted are sown too close to fresh manure.

3. Apply manure to the soil before crops are planted.

Sprinkle manure on the soil surface to prevent the soil from getting direct sunlight.

Appendix G: Method of making compost (FAO 1995a, Gilbert and Hadfield 1987).

Soil compost

1. Locate compost in a shady area to prevent it from drying out.

2. Put plants and other organic matter in a pile over a surface area.

3. Chop materials into small particles to incorporate them into the soil in order to speed up the break down of organic matter.

4. Build compost materials in layers of 15 to 20cm thick with coarsest materials at the bottom to allow drainage when it rains and 2 to 3cm of soil in between compost layers OR mix wet, dry, soft and hard materials thoroughly before building a heap.

5. If materials are mixed together, then build them in a heap in layers.

6. Add water, layer after layer to wet materials to get ideal moisture.

7. Build compost not wider or higher than 1 to 1.5m depending on the amount of materials available.

8. Cover the heap in dry areas with banana leaves or other materials such as black plastic sheeting pinned to the ground to prevent moisture from evaporating.

9. Turn over the heap with digging fork or spade after about 15 days to allow all sides of the heap to get adequate moisture and temperatures in order to decay.

10. Turn the heap again after five weeks, putting the outer parts to the centre of the heap.

11. Check the moisture content and add water if necessary to facilitate fermentation.

12. Avoid too much water in rainy seasons by covering the heap with banana leaves, black plastic sheeting or other materials that can prevent water.

13. Turn the heap or add dry materials if the heap has become too wet.

14. Compost should be ready for use after three months when it is dark brown and crumbly with earthy aroma.

15. Remove particles that are not fully decomposed or leave compost heap for some more days to continue decomposing.

16. To ensure a continuous supply of compost, build three heaps with one-month interval.

17. Mix three spades of old manure and two spades of compost per square metre.

Note: Avoid using diseased materials, as temperatures may not be adequate enough to kill disease-causing organisms.

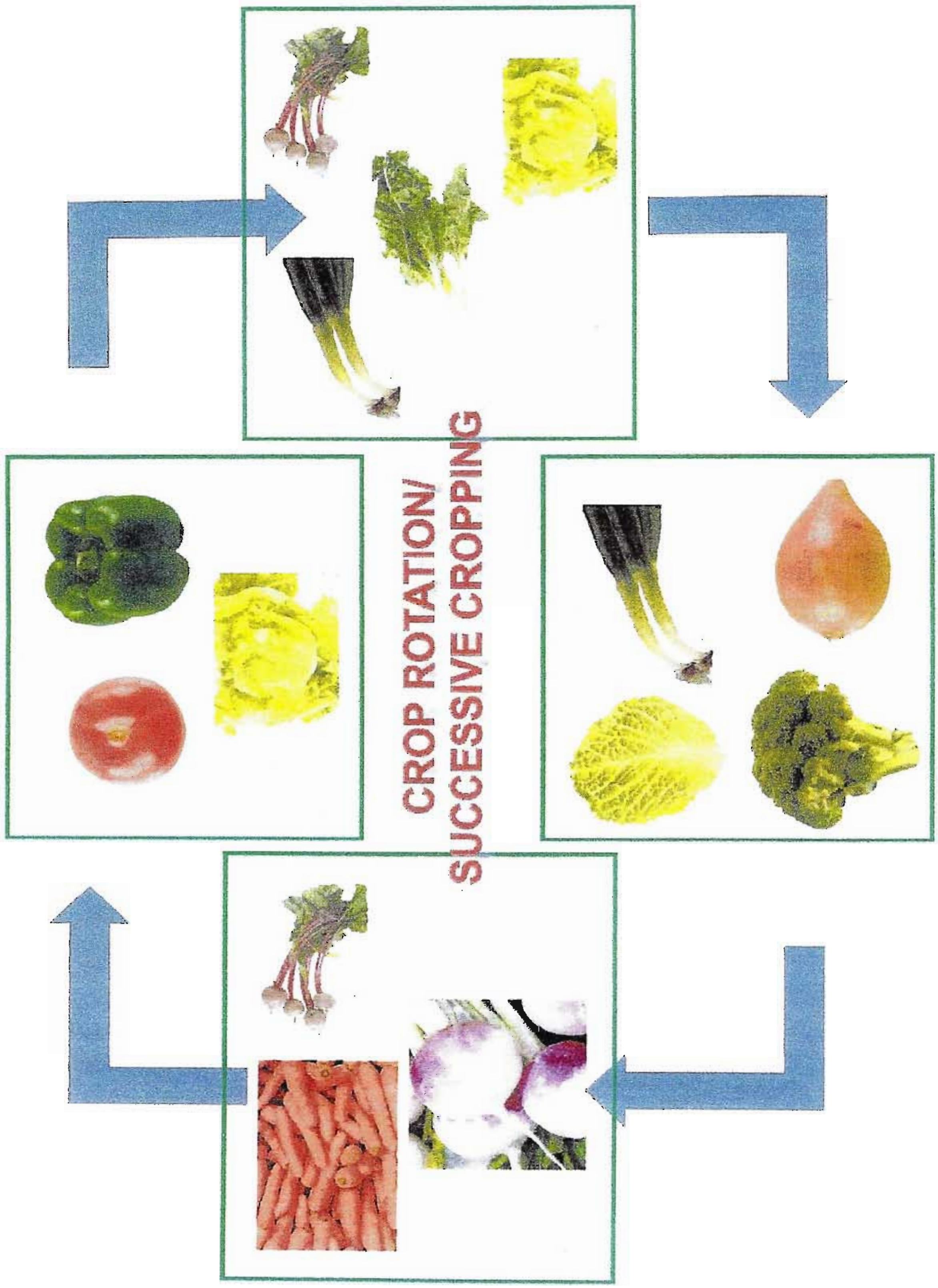
Appendix H: Quantities of plants grown per square and plants spacing (Bartholomew 1996, Addison 2002).

Vegetables	Quantity of plants per square	Plants spacing (cm)
Beets	16	30
Broccoli	1	7.5
Carrots	16	7.5
Chard (Swiss)	4	15
Chinese cabbage	1	30
Garlic	4	15
Leeks	9	10
Lettuce	4	15
Onions	16	7.5
Pepper	1	30
Radish	16	7.5
Tomato	1	30
Turnips	16	7.5

Appendix I: Crop families (Gilbert and Hadfield 1987).

Crop families	Examples of vegetables
Cruciferous crops/ cabbage family	Cauliflowers, cabbages, broccoli, Brussels sprouts, onions, leeks, celery, mustard, collards, kale.
Root crops	Carrots, beetroot, parsnips, turnips, kohlrabi, sweet potato.
Solanaceous crops	Potato, tomato, peppers, eggplant, lettuce, swiss chard.
Leguminous crops	Peas, beans.
Miscellaneous crops	Leeks, lettuce, onion, radish, spinach, sweet corn, Swiss chard, sweet potato.
Cucurbits	Squash, pumpkin, cucumber, melons.

Appendix J: Rotational / successive cropping



Appendix K: Methods of water management in the garden (FAO 2001).

Water management in dry areas	Water management in wet areas
Mulch the garden to retain soil moisture.	Avoid mulching as mulches keep the soil too wet.
Select drought resistant crops.	Select water-loving plants such as green leafy vegetables.
Select short-term vegetables.	Establish raised beds.
Use kitchen water waste for irrigation.	Establish drainage canals.
Make a basin-like or sunken area around the crop to prevent water from running off.	Make heaps of soil around crops to drain off surplus water.
Grow vegetables under the shade.	
Remove weeds to prevent competition with vegetables for soil moisture.	

Appendix L: Method of applying mulching in the garden (FAO 1995a, 2001, Guanzon and Holmer 2002).

1. Fertilise and rake the to level the surface.

2. The soil should be free from weeds and have adequate moisture before mulching.

3. Apply mulches to warm-season vegetables when the soil is adequately warm for plant growth.

4. Apply mulches when plants are big enough not to be covered.

5. Spread mulches over the soil surface around plants.

6. Newspaper is used as organic material for mulching since it decomposes easily.

7. Weigh newspaper to the ground with soil to prevent wind from blowing it away.

8. Keep mulches at least one centimetre away from the stems of plants.

Note: Dry mulch burns plants. Mulching too early at the fall of winter may be harmful to the plants.

APPENDIX M: QUESTIONNAIRE

COMMUNITY NAME……………………………………………………………………

NAME OF HOUSEHOLD MEMBER…………………………………………………..

SECTION A: QUESTIONS TO BE ASKED TO INDIVIDUAL HOUSEHOLDS.

(Please tick in an appropriate box and fill in where necessary).

1. How many people live in this household and what are their ages and physiological status?

Age/ physiological status		**Number of household members**
1	Children under one year	
2	Children 1-5 years	
3	Children 6-14 years	
4	Women of child-bearing age (15-49)	
5	Pregnant women	
6	Lactating women	
7	Women 50 years+	
8	Men 15 years+	

2. Do you have a home garden?

1. Yes (skip to Q4) ☐
2. No ☐

3. If no, what are the reasons for not having a home garden?

1. Lack of access to land ☐
2. Lack of time ☐
3. Lack of water ☐
4. Poor soils ☐
5. Limited labour ☐
6. Other (specify)……………………………………………………………………… ☐

(Then skip to Q14)

4. How big is your garden?...

5. What factors determine your choice of vegetables?

Factors		Very much	To some extent	Not at all
1	Family taste			
2	Soil type			
3	Climate			
4	Seed availability			
5	Nutrients			
6	Other (specify)..			

6. What crops were grown in your garden over the last year?

Crops		Crops grown (tick)
1	Maize	
2	Dry beans	
3	Green beans	
4	Beets	
5	Broccoli	
6	Carrots	
7	Chinese cabbage	
8	Garlic	
9	Leeks	
10	Lettuce	
11	Onion	
12	Pepper	
13	Radish	
14	Swish chard	
15	Tomato	
16	Turnips	
17	Other (specify)..	

7. How do you improve soil to produce health plants in your garden?

1. Soil compost ☐
2. Green manure ☐
3. Animal manure ☐
4. Synthetic fertilisers ☐
5. Other (specify)..

8. How do you control weeds from your garden?

1. Mulching ☐
2. Hand removal ☐
3. Grow plants close together ☐
4. Other (specify)..

9. What is the main function of the garden at present?

1. Food for consumption ☐
2. Food for sale ☐
3. Both ☐

10. Are there times in a year when you buy vegetables?

1. Summer (Oct, Nov, Dec) ☐
2. Autumn (Jan, Feb, Mar) ☐
3. Winter (Apr, May, Jun) ☐
4. Spring (Jul, Aug, Sep) ☐
5. Never ☐

11. How do you control pests and diseases from your garden?

Pests and disease control measures		Measures applied (tick)
1	Rotational/ successive cropping	
2	Crop diversification	
3	Soil composting	
4	Insects repellent crops	
5	Removal of diseased crops	
6	Use ash	
7	Home made spray (soap, chilli etc)	
8	Grow plants in the right season	
9	Use synthetic chemicals	
10	Other (specify)...	

12. What are the factors that constrain production in your garden?

Potential problems in home gardening		Problems encountered (tick)
1	Limited labour	
2	Limited time	
3	Limited skills	
4	Limited seeds	
5	Theft	
6	Shortage of land	
7	Animal interference	
8	Lack of compost materials	
9	Poor soils	
10	Water scarcity	
11	Diseases	
12	Other (specify)...	

13. What are the factors that encourage you to grow vegetables in your gardens?

1. Extension services ☐
2. Water availability ☐
3. Time ☐
4. Cost-effectiveness ☐
5. Varied diet ☐
6. Nutrition ☐
7. Other (specify)..

14. How many times are the following foods included in the family diets?

Foods		**Frequency consumption**			
		Per week	**Per month**	**Seldom**	**Never**
1	Beets				
2	Broccoli				
3	Carrots				
4	Chinese cabbage				
5	Garlic				
6	Leeks				
7	Lettuce				
8	Onions				
9	Pepper				
10	Radish				
11	Spinach				
12	Tomato				
13	Turnips				
14	Imifino				
15	Milk				
16	Eggs				
17	Beef offal				
18	Fish				

15. How much of the following foods do children between 1 and 5 years old eat per day?

Vitamin A rich animal foods		**Quantity of foods consumed**
1	Eggs	(Number)
2	Milk	(Cups)

SECTION B: GUIDELINES FOR PLENARY DISCUSSIONS

Household perceptions of the acceptance and feasibility of the garden unit.

1. Do you think the garden unit can significantly increase production and variety of vegetables in your garden?

1. Yes
2. No

2. What do you think are the advantages and disadvantages of the garden unit?

Advantages		**Disadvantages**	
1		1	
2		2	
3		3	
4		4	
5		5	
6		6	
7		7	
8		8	
9		9	
10		10	

3. Would you apply the model in your garden?

1. Yes
2. No

Comments/suggestions...

....

....

....

THANK YOU.

Data labels for appendix N

AREA_NO	area number
HHNO	household number
CH1	children under 1 year old
CH5	children aged 1 to 5 years old
CH14	children aged 6 to 14 years old
W_CH	women of children bearing age
PREG_W	pregnant women
LACT_W	lactating mothers
OLD_W	women aged 50 years and above
MEN_15	men aged 15 years and above
TOT_HM	total household members
H_GAR	presence or absence of home gardens
LACK_FEN	lack of fencing
LACK_SKI	lack of skills
COM_GAR	community garden
GAR_SIZ	garden size
TASTE	taste
SOIL_TY	soil types
CLIMATE	climate
SEED_AV	seed availability
NUTRIENT	nutrients
MAIZE	maize
DRY_BEA	dry beans
GREEN_BE	green beans
BEET	beetroot
BROCOLI	broccoli
CARROT	carrots
CABBAGE	cabbage
GARLIC	garlic
LEEK	leeks
LETTUCE	lettuce
ONION	onion
PEPPER	pepper
RADISH	radish
SPI	spinach
TOMATO	tomato
TURNIP	turnips
POTATO	potato
SWEET_P	sweet potato
PEAS	peas
MADUMBE	madumbe
COMPOST	compost
GREEN_M	green manure
ANIMAL_M	animal manure
FERTILIS	fertiliser
WEED-MEA	weed control measures
GARDEN-F	garden function
SHORTVG	time vegetables are not grown
ROTATION	crop rotation
DIVERS	crop diversification
SOILCOMP	soil compost
REPEL_IN	insect repellent crops
SANITATI	sanitation
USEASH	use ash
H_SPRAY	home made spray
RIGHTSEA	grow vegetables in right season
CHEMICAL	chemicals
NO_CONT	don't control pests
LTDLABOR	limited labour
LTDTIME	limited time
LTDSEED	limited seeds
LTDSKILL	limited skills
THEFT	theft
LTDLAND	limited land
ANIMAL	animal interference
LTDCOMP	limited compost materials
SOILS	poor soils
LTDWATER	limited water
TIME	adequate time
COSTEFF	cost-effectiveness

VARIEDDI	varied diet
NUTRITIO	nutrition
HUNGER	hunger alleviation
BEET_W	consumption of beets per week
BEET_M	consumption of beets per month
BEET_S	beets seldom consumed
BEET_N	beets never consumed
CAR_W	consumption of carrots per week
CAR_M	consumption of carrots per month
CAR_S	carrots seldom consumed
CAR_N	carrots never consumed
GAR_W	consumption of garlic per week
GAR_M	consumption of garlic per month
GAR_S	garlic seldom consumed
GAR_N	garlic never consumed
LEE_W	consumption of leeks per week
LEE_M	consumption of leeks per month
LEE-S	leeks seldom consumed
LEE_N	leeks never consumed
LET_W	consumption of lettuce per week
LET_M	consumption of lettuce per month
LET_S	lettuce seldom consumed
LET_N	lettuce never consumed
ONI_W	consumption of onion per week
ONI_M	consumption of onion per month
ONI_S	onion seldom consumed
ONI_N	onion never consumed
PEP_W	consumption of pepper per week
PEP_M	consumption of pepper per month
PEP_S	pepper seldom consumed
PEP_N	pepper never consumed
RAD_W	consumption of radish per week
RAD_M	consumption of radish per month
RAD_S	radish seldom consumed
RAD_N	radish never consumed
SPI_W	consumption of spinach per week
SPI_M	consumption of spinach per month
SPI_S	spinach seldom consumed
SPI_N	spinach never consumed
TOM-W	consumption of tomato per week
TOM_M	consumption of tomato per month
TOM_S	tomato seldom consumed
TOM_N	tomato never consumed
TUR_W	consumption of turnip per week
TUR_M	consumption of turnip per month
TUR_S	turnip seldom consumed
TUR_N	turnip never consumed

IMI_W	consumption of imifino per week	C_MILK	cups of milk consumed per day by 1 to 5 year olds
IMI_M	consumption of imifino per month		
IMI_S	imifino seldom consumed		
IMI_N	imifino never consumed		
MILK_W	consumption of milk per week		
MILK_M	consumption of milk per month		
MILK_S	milk seldom consumed		
MILK_N	milk never consumed		
EGG_W	consumption of eggs per week		
EGG_M	consumption of eggs per month		
EGG_S	eggs seldom consumed		
EGG_N	eggs never consumed		
OFFAL_W	consumption of beef offal per week		
OFFAL_M	consumption of beef offal per month		
OFFAL_S	beef offal seldom consumed		
OFFAL_N	bee offal never consumed		
FISH_W	consumption of fish per week		
FISH_M	consumption of fish per month		
FISH_S	fish seldom consumed		
FISH_N	fish never consumed		
N_EGG	number of eggs consumed per day by 1 to 5 year olds		

APPENDIX N: SURVEY DATA

AREA NO	HHNO	CH1	CH5	CH14	W CH	PREG W	LACT W	OLD W	MEN15	TOL HM	H GAR	LACK SP	LACK TI	LACK WA	POOR SO	LTD LAB	LACK FEN	LACK INC	LACK SKI	COM GAR	GARD SIZ	TASTE	SOIL TY	CLIMATE	SEED AV	NUTRIENT	MAIZE	DRY BEA	GREEN BE
1	1	1	1	1	0	0	1	1	7	12	0	0	0	1	0	0	1	0	0	0	-99	-99	-99	-99	-99	-99	-99	-99	-99
1	2	0	0	1	1	0	0	0	0	2	1	-99	-99	-99	-99	-99	-99	-99	-99	-99	-1	1	1	2	1	1	1	1	1
1	3	0	1	0	4	0	0	2	1	8	1	-99	-99	-99	-99	-99	-99	-99	-99	-99	200	3	2	3	1	3	1	1	0
1	4	0	0	1	1	0	0	0	0	2	0	0	0	1	1	0	0	0	0	0	-99	-99	-99	-99	-99	-99	-99	-99	-99
1	5	0	1	2	1	0	0	1	2	7	1	-99	-99	-99	-99	-99	-99	-99	-99	-99	200	2	3	1	2	3	0	1	0
1	6	0	1	2	1	0	0	0	1	5	0	1	0	1	0	0	0	0	0	0	-99	-99	-99	-99	-99	-99	-99	-99	-99
1	7	0	2	1	1	0	0	0	1	5	0	0	0	1	0	0	0	0	0	0	-99	-99	-99	-99	-99	-99	-99	-99	-99
1	8	0	0	1	3	0	0	1	2	7	0	0	0	1	0	0	0	0	0	0	-99	-99	-99	-99	-99	-99	-99	-99	-99
1	9	0	0	2	3	0	0	1	0	7	0	0	0	0	0	0	0	0	0	1	-99	-99	-99	-99	-99	-99	-99	-99	-99
1	10	0	1	2	1	0	0	0	2	6	0	0	0	1	0	0	1	0	0	0	-99	-99	-99	-99	-99	-99	-99	-99	-99
1	11	0	1	3	2	0	0	2	4	12	1	-99	-99	-99	-99	-99	-99	-99	-99	-99	14	1	1	2	1	1	0	1	0
1	12	2	2	4	2	0	0	1	1	12	0	0	0	0	0	0	1	1	0	0	-99	-99	-99	-99	-99	-99	-99	-99	-99
1	13	0	1	1	1	0	0	2	2	7	0	0	0	1	0	0	1	0	0	0	-99	-99	-99	-99	-99	-99	-99	-99	-99
1	14	0	1	2	1	0	0	1	1	6	0	0	0	1	0	0	1	0	0	0	-99	-99	-99	-99	-99	-99	-99	-99	-99
1	15	0	0	1	3	0	0	2	1	7	0	0	0	0	0	0	1	0	0	0	-99	-99	-99	-99	-99	-99	-99	-99	-99
1	16	1	1	0	1	0	0	0	1	4	0	0	0	1	0	0	1	1	0	0	-99	-99	-99	-99	-99	-99	-99	-99	-99
1	17	0	2	3	2	0	0	2	2	11	0	0	0	1	0	0	0	0	0	0	-99	-99	-99	-99	-99	-99	-99	-99	-99
1	18	0	0	2	3	0	0	1	4	10	0	0	0	0	0	0	1	0	0	0	-99	-99	-99	-99	-99	-99	-99	-99	-99
1	19	0	2	2	4	0	0	1	3	12	0	0	0	1	0	0	1	0	0	0	-99	-99	-99	-99	-99	-99	-99	-99	-99
1	20	0	1	1	1	0	0	1	3	7	0	0	0	0	0	0	1	0	0	0	-99	-99	-99	-99	-99	-99	-99	-99	-99
1	21	1	2	2	3	0	1	0	1	10	0	0	0	1	0	0	1	0	0	0	-99	-99	-99	-99	-99	-99	-99	-99	-99
1	22	0	0	4	3	0	0	1	1	9	0	0	0	0	0	1	1	0	0	0	-99	-99	-99	-99	-99	-99	-99	-99	-99
1	23	0	0	2	1	0	0	1	2	6	0	1	0	1	0	0	0	0	0	0	-99	-99	-99	-99	-99	-99	-99	-99	-99
1	24	0	3	1	3	0	0	1	1	9	0	0	1	1	0	0	0	0	0	0	-99	-99	-99	-99	-99	-99	-99	-99	-99
1	25	0	4	5	12	0	0	1	8	30	0	0	0	0	0	0	1	0	0	0	-99	-99	-99	-99	-99	-99	-99	-99	-99
2	26	2	0	1	1	0	0	1	2	7	0	0	0	1	0	0	0	0	1	0	-99	-99	-99	-99	-99	-99	-99	-99	-99
2	27	0	1	4	5	0	0	3	4	17	0	0	0	1	0	0	1	0	0	0	-99	-99	-99	-99	-99	-99	-99	-99	-99
2	28	0	0	2	3	0	0	0	1	5	1	-99	-99	-99	-99	-99	-99	-99	-99	-99	200	3	1	3	2	1	1	1	0
2	29	0	0	5	5	0	0	1	3	14	0	0	0	1	0	0	1	0	0	0	-99	-99	-99	-99	-99	-99	-99	-99	-99
2	30	1	1	2	3	0	1	1	3	12	0	0	0	1	0	0	1	0	0	0	-99	-99	-99	-99	-99	-99	-99	-99	-99
2	31	1	1	2	3	0	1	0	2	9	1	-99	-99	-99	-99	-99	-99	-99	-99	-99	100	1	2	3	1	2	0	0	0
2	32	0	0	1	1	0	0	0	2	4	0	0	1	1	0	0	1	0	0	0	-99	-99	-99	-99	-99	-99	-99	-99	-99
2	33	3	2	2	1	0	1	0	1	10	0	0	0	1	0	0	0	0	0	0	-99	-99	-99	-99	-99	-99	-99	-99	-99
2	34	0	2	4	19	0	0	0	6	31	0	1	0	1	0	0	0	0	0	0	-99	-99	-99	-99	-99	-99	-99	-99	-99
2	35	0	0	4	1	0	0	0	1	6	0	0	0	1	0	0	1	0	0	0	-99	-99	-99	-99	-99	-99	-99	-99	-99
2	36	0	0	5	2	0	0	0	0	7	1	-99	-99	-99	-99	-99	-99	-99	-99	-99	100	3	3	3	1	1	0	1	0
2	37	0	0	1	1	0	0	1	1	4	0	0	0	1	1	0	1	0	0	0	-99	-99	-99	-99	-99	-99	-99	-99	-99
2	38	0	1	2	2	1	0	2	2	10	0	0	0	0	0	0	1	0	0	0	-99	-99	-99	-99	-99	-99	-99	-99	-99
2	39	1	1	2	7	1	1	2	4	19	0	0	0	1	0	0	1	0	0	0	-99	-99	-99	-99	-99	-99	-99	-99	-99
2	40	1	1	2	4	0	1	1	2	12	0	0	0	1	0	0	1	0	0	0	-99	-99	-99	-99	-99	-99	-99	-99	-99
2	41	0	1	3	2	0	0	1	0	6	1	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99
2	42	0	0	0	0	0	0	1	5	6	0	1	0	1	0	0	0	0	0	0	-99	-99	-99	-99	-99	-99	-99	-99	-99
2	43	0	3	3	0	0	0	0	1	7	0	1	0	1	1	0	0	0	0	0	-99	-99	-99	-99	-99	-99	-99	-99	-99
2	44	0	0	0	2	0	0	1	2	5	0	0	0	1	0	0	0	0	0	0	-99	-99	-99	-99	-99	-99	-99	-99	-99
2	45	0	0	3	3	0	0	0	3	9	1	-99	-99	-99	-99	-99	-99	-99	-99	-99	6	1	3	3	2	3	1	0	0
2	46	1	1	3	2	0	1	0	1	9	1	-99	-99	-99	-99	-99	-99	-99	-99	-99	6	2	3	3	1	1	0	0	0
2	47	1	1	2	1	0	0	1	1	7	0	0	0	0	0	0	1	0	0	0	-99	-99	-99	-99	-99	-99	-99	-99	-99
2	48	1	1	1	1	0	0	1	1	6	1	-99	-99	-99	-99	-99	-99	-99	-99	-99	12	1	1	1	1	1	1	1	0
2	49	0	1	2	0	0	0	1	1	5	1	-99	-99	-99	-99	-99	-99	-99	-99	-99	15	1	1	1	1	1	1	1	0
2	50	0	0	1	3	0	0	1	1	6	1	-99	-99	-99	-99	-99	-99	-99	-99	-99	30	1	1	2	2	2	1	1	0
2	51	0	1	1	3	0	0	1	1	7	0	0	0	1	0	0	1	0	0	0	-99	-99	-99	-99	-99	-99	-99	-99	-99
2	52	0	2	0	1	0	0	1	1	4	0	0	0	1	0	0	1	0	0	0	-99	-99	-99	-99	-99	-99	-99	-99	-99

BEETS	BROCOLI	CARROT	CABBAGE	GARLIC	LEEK	LETTUCE	ONION	PEPPER	RADISH	SPI	TOMATO	TURNIP	POTATO	SWEET P	PEAS	MADUMBE	COMPOST	GREEN M	ANIMAL M	FERTILIS	WEED MEA	GARDEN F	SHORTVG	ROTATION	DIVERS	SOILCOMP	REPEL IN
-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99
1	0	1	1	0	0	0	1	1	0	1	1	0	0	0	1	0	0	0	1	0	1	1	2	1	0	1	0
0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	1	2	1	5	0	0	0	0
-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	2	1	3	0	0	0	0
-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99
-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99
-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99
-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99
-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99
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SANITATI	USEASH	H SPRAY	RIGHTSEA	CHEMICAL	NO CONT	LTDLABOR	LTDTIME	LTDSEED	LTDSKILL	THEFT	LTDLAND	ANIMAL	LTDCOMP	SOILS	LTDWATER	PESTS	EXT	WATERAVA	TIME	COSTEFFE	VARIEDDI	NUTRITIO	HUNGER	BEET W	BEET M	BEET S	BEET N
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BROC W	BROC M	BROC S	BROC N	CAR W	CAR M	CAR S	CAR N	CAB W	CAB M	CAB S	CAB N	GAR W	GAR M	GAR S	GAR N	LEE W	LEE M	LEE S	LEE N	LET W	LET M	LET S	LET N	ONI W	ONI M	ONI S	ONI N	PEP W	PEP M	PEP S	PEP N	RAD W
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RAD M	RAD S	RAD N	SPI W	SPI M	SPI S	SPI N	TOM W	TOM M	TOM S	TOM N	TUR W	TUR M	TUR S	TUR N	IMI W	IMI M	IMI S	IMI N	MILK W	MILK M	MILK S	MILK N	EGG W	EGG M	EGG S	EGG N	OFFAL W	OFFAL M	OFFAL S	OFFAL N	FISH W	FISH M	FISH S	FISH N	N EGG	C MILK
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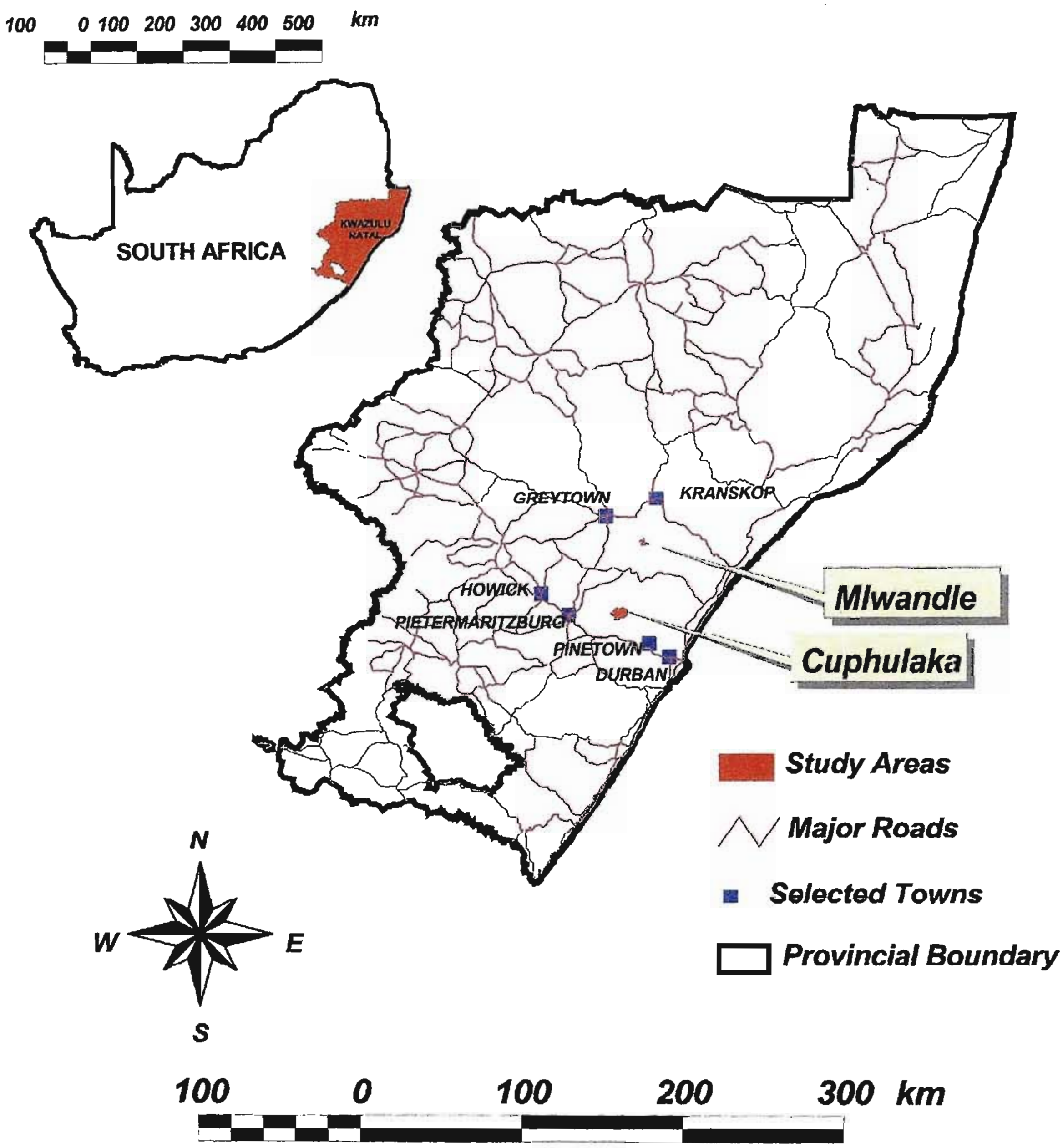
Appendix O

Map of KwaZulu Natal



Appendix P: An evaluation model of household vitamin A requirements

household composition	*household size*	*vitamin A requirements per person (RE)*	*household vitamin A requirements (RE)*	*vitamin A rich vegetables*	*frequency consumption per week*
child 1-5	2	400	800	beets	0
child 6-14	3	600	1800	broccoli	0
women of child-bearing age	2	600	1200	carrots	2
pregnant women	0	800	0	c.cabbage	1
lactating mothers	0	850	0	garlic	0
women 50 years+	2	600	1200	leeks	0
Men 15 years +	2	700	1400	lettuce	0
				onions	3
Totals by age and gender				pepper	0
total child 1-5	2		800	radish tops	0
total child 6-14	3		1800	swiss chard	0
female 15yrs+	4		2400	tomato	7
male 15yrs+	2		1400	turnip greens	0
adults >15yrs+	6		3800		
	11		**6400**		
		per day	*6400*		
		per week	*44800*		
		per season	*358400*		

Appendix Q: An evaluation model of adequacy of vitamin A consumed from vegetables by 1 to 5 year olds

vitamin A rich vegetables	*vitamin A content RE/100g*	*RE/ 132g*	*vitamin A intake per person per week (RE)*	*averarge daily vitamin A intake per person (RE)*	*average daily vitamin A intake for 1-5 yr olds (RE)*	*adequacy of vitamin A intake (%)*
beets	5.4	7	0	0	0	0
broccoli	340	449	0	0	0	0
carrots	1250	1650	3300	471	943	118
c.cabbage	12	16	16	2	5	1
garlic	0	0	0	0	0	0
leeks	0.8	1	0	0	0	0
lettuce	162	214	0	0	0	0
onions	0	0	0	0	0	0
pepper	501	661	0	0	0	0
radish tops	542	715	0	0	0	0
swiss chard	969	1279	0	0	0	0
tomato	110	145	1016	145	290	36
turnip greens	1060	1399	0	0	0	0
		503			**95**	**12**

vegetable intake by 1-5 year olds	**132 grams**

Appendix R: An evaluation model of adequacy of vitamin A consumed from vegetables by 6 to 14 year olds

vitamin A rich vegetables	*vitamin A content RE/100g*	*RE/ 140g*	*vitamin A intake per person per week (RE)*	*averarge daily vitamin A intake per person (RE)*	*average daily vitamin A intake for 6-14 yr olds (RE)*	*adequacy of vitamin A intake (%)*
beets	5.4	8	0	0	0	0
broccoli	340	476	0	0	0	0
carrots	1250	1750	3500	500	1500	83
c.cabbage	12	17	17	2	7	0
garlic	0	0	0	0	0	0
leeks	0.8	1	0	0	0	0
lettuce	162	227	0	0	0	0
onions	0	0	0	0	0	0
pepper	501	701	0	0	0	0
radish tops	542	759	0	0	0	0
swiss chard	969	1357	0	0	0	0
tomato	110	154	1078	154	462	26
turnip greens	1060	1484	0	0	0	0
		533			**151**	**8**

vegetable intake by 6-14 yr olds	**140 grams**

Appendix S: An evaluation model of adequacy of vitamin A consumed from vegetables by adults aged 15 years and above and by households

vitamin A rich vegetables	*vitamin A content RE/100g*	*RE/ 140g*	*vitamin A intake per person per week (RE)*	*averarge daily vitamin A intake per person (RE)*	*average daily vitamin A intake for 15 yr olds+ (RE)*	*adequacy of vitamin A intake (%)*
beets	5.4	10	0	0	0	0
broccoli	340	598	0	0	0	0
carrots	1250	2200	4400	629	3771	99
c.cabbage	12	21	21	3	18	0
garlic	0	0	0	0	0	0
leeks	0.8	1	0	0	0	0
lettuce	162	285	0	0	0	0
onions	0	0	0	0	0	0
pepper	501	882	0	0	0	0
radish tops	542	954	0	0	0	0
swiss chard	969	1705	0	0	0	0
tomato	110	194	1355	194	1162	31
turnip greens	1060	1866	0	0	0	0
		670			**381**	**10**

vegetable intake by 15 yr olds+	**176 grams**

average household vitamin A adequacy	***10***

Appendix T: An evaluation model of vegetable servings required by households, vegetable and vitamin A adequacies of the garden unit/s

vegetable servings required

household composition	***servings required per person***	***total servings required***	***average size per serving (grams)***	***total vegetables required per day***
child 1-5	3	5	80	424
child 6-14	4	12	80	960
female >15	4	16	80	1280
male>15	5	10	80	800
	per day	***43***	***80***	***3464***
	per week	***303***		***24248***
	per season	***2425***		***193984***

vegetable servings produced	***yield per garden unit (grams)***	***number of garden units***	***total Yield per serving (grams)***	***total servings produced***
	16745	11	184195	2302

produce adequacy	
amount produced	*95*
servings produced	*95*
produce vitamin A adequacy	
vitamin A per garden unit	*71043*
total vitamin A from produce	*781469*
vitamin A adequacy of the requirements (percent)	***218***

numbers used in model		
days in week	*7*	*days*
weeks in season	*8*	*weeks*

APPENDIX U: Estimation of vegetable and vitamin A yields per garden unit

vitamin A rich vegetables	*quantity of plants per garden unit*	*average weight per plant (grams)*	*estimated yield per garden unit (grams)*	*vitamin A content RE/100g*	*total vitamin A per garden unit*
beetroot	16	90g	1440	5.4	78
beetroot leaves	10 leaves per plant	12g/ leaf (10)	1920	510	9792
broccoli	1	500g	500	340	1700
cabbage	1	305g	305	12	37
carrots	16	60g	960	1250	12000
garlic	4	2g/glove	80	0	0
leeks	9 (10 leaves per plant)	2g/glove	180	162	292
lettuce	4 (x2)	220g	1760	0	0
onion	16	30g	480	0	0
pepper	8 fruits/ plant (x2)	120g/fruit	1920	501	9619
radish roots	16	30g	480	0.8	4
radish tops	10 leaves per plant	12g/ leaf	1920	542	10406
swiss chard	4 (10 leaves per plant)	90g (125ml)	480	969	4651
tomato	8 fruits/plant (x2)	120g/fruit	1920	110	2112
turnip roots	16	30g	480	0	0
turnip greens	10 leaves per plant	12g/ leaf	1920	1060	20352
			16745		**71043**

Note: edible portions of raw vegetables (in grams) were adapted from Langenhoven *et al.* (1986)

Data labels for evaluation model presented in Appendix V

HH_num	household number.
HH_size	household size.
Vit_reg	vitamin A requirements
Vit_int5	vitamin A intake of children under 5 years old.
Vit_int14	vitamin A intake of children 6-14 years old.
Vit_int15	vitamin A intake of adults 15 years and above.
Vit_intH	vitamin A intake of individual households.
Veg_req	vegetable requirements of households.
Veg_prod	vegetable servings produced.
Veg_adeq	vegetable adequacy of the garden unit.
Vit_p_ad	vitamin A adequacy of the garden unit.

Appendix V: Evaluation model summary

HH_num	HH_size	vit_req	vit_int5	vit_int14	vit_int15	vit_intH	veg_req	veg_prod	veg_adeq	vit_p_ad
HH1	12	7950	17	12	13	14	3004	2512	84	191
HH2	2	1200	-	13	17	15	448	419	93	211
HH3	8	4700	9	-	0	8	1772	1675	94	216
HH4	2	1200	-	11	13	12	448	419	93	211
HH5	7	4200	32	22	26	27	1604	1465	91	211
HH6	5	2900	33	23	27	28	1100	1047	95	219
HH7	5	2700	1	1	0	1	1025	1047	102	235
HH8	7	4400	-	0	0	0	1680	1465	87	202
HH9	6	3600	-	1	1	1	1344	1256	93	211
HH10	6	3600	1	1	1	1	1380	1256	91	211
HH11	12	7400	35	24	28	29	2836	2512	89	206
HH12	10	5700	49	35	42	42	2145	2093	98	223
HH13	7	4200	45	32	38	38	1604	1465	91	211
HH14	6	3500	45	31	38	38	1324	1256	95	217
HH15	7	4300	-	43	53	48	1624	1465	90	207
HH16	3	1700	19	-	16	17	652	628	96	224
HH17	11	6400	12	8	10	10	2425	2302	95	218
HH18	12	7100	24	17	20	20	2705	2512	93	214
HH19	14	8000	3	2	2	2	3058	2930	96	222
HH20	7	4300	1	1	1	1	1660	1465	98	207
HH21	9	5350	40	28	32	33	1921	1884	98	213
HH22	9	5500	-	2	2	2	2072	1884	91	208
HH23	6	3800	-	0	0	0	1456	1256	86	200
HH24	9	4900	3	2	2	2	1845	1884	102	233
HH25	30	18000	16	16	13	13	6866	6279	91	211
HH26	5	3200	-	16	19	17	1232	1047	85	198
HH27	17	10400	3	2	0	2	3956	3558	90	207
HH28	6	3700	-	11	13	12	1400	1256	90	206
HH29	14	8700	-	10	12	11	3304	2930	89	204
HH30	11	6950	3	2	2	2	2556	2302	90	201
HH31	9	5650	3	2	2	2	2052	1884	92	202
HH32	5	3200	-	2	2	2	1232	1047	85	198
HH33	7	4150	3	2	2	2	1473	1465	99	214
HH34	31	18800	3	2	2	2	7129	6489	91	209
HH35	6	3700	-	38	45	42	1400	1256	90	206
HH36	7	4200	-	32	40	36	1568	1465	93	211
HH37	4	2500	-	36	43	40	952	837	88	203
HH38	10	6200	21	15	17	18	2276	2093	92	205
HH39	18	11450	21	15	17	19	4180	3768	90	199
HH40	11	6850	24	17	19	18	2500	2302	92	204
HH41	7	4000	35	25	31	30	1492	1465	98	222
HH42	6	4100	-	-	48	48	1624	1256	77	186
HH43	8	4700	58	41	50	50	1772	1675	94	216
HH44	5	3200	-	-	60	60	1232	1047	85	198
HH45	9	5700	-	39	45	42	2184	1884	86	200
HH46	8	4950	32	22	25	26	1772	1675	94	205
HH47	6	3500	53	37	45	45	1324	1256	95	217
HH48	5	2900	15	11	13	13	1100	1047	95	219
HH49	5	2900	14	10	11	12	1100	1047	95	206
HH50	6	3700	-	7	9	8	1400	1256	90	217
HH51	7	4100	31	22	26	26	1548	1465	95	217
HH52	5	2700	20	-	17	19	1025	1047	102	235