Nutritional Status of South Africans: Links to Agriculture and Water

Friedeburg Wenhold & Mieke Faber

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Water Research Commission

NUTRITIONAL STATUS OF SOUTH AFRICANS: LINKS TO AGRICULTURE AND WATER

Report to the Water Research Commission

as part of the project

"Nutritional value and water use of indigenous crops for improved livelihoods"

by

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FOREWORD

This review is one of the deliverables of the solicited, collaborative research project "Nutritional value and water use of indigenous crops for improved livelihoods", initiated, managed and funded by the Water Research Commission (Project No K5/1579/4; 01/04/2005-31/03/2010). According to the terms and conditions of that contract, the title of this literature study is "Current nutritional status of the South African population with specific reference to malnutrition".

In an attempt to make a more significant contribution to the overall project, and to generate new knowledge for the South African nutrition community, the authors decided to expand the mandate by additionally focusing on the roles that agriculture and water can play in determining nutritional status. It follows, therefore, that a more appropriate title for this literature review is ***"Nutritional status of South Africans: Links to agriculture and water",*** and that is how we are presenting it. We are indebted to Prof Wim van Averbeke (Tshwane University of Technology) for writing the section on livestock production. The contributions of Prof Andre Oelofse from the Centre for Nutrition (University of Pretoria) and Prof Kelebogile Setiloane from the University of Delaware (USA) in respect of chapters 2 and 3 respectively are duly acknowledged.

It is our sincere wish that this literature review will contribute to the growth of the collaboration between nutrition and agriculture in South Africa in the spirit of "fewer drops, more crops, most nutrition".

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September 2008

LIST OF ABBREVIATIONS

ADA	American Dietetic Association
AI	Adequate Intakes
BMI	Body mass index; expressed as weight in kg / height in m^2
CASP	Comprehensive Agricultural Support Programme
DFID	Department for International Development
DHS	Demographic and Health Survey
DRI	Dietary Reference Intakes
EAR	Estimated Average Requirement
EPI	Expanded Programme of Immunization
EPWP	Expanded Public Works Programme
F	Fluorine – chemical element
FAO	Food and Agricultural Organisation
FBDG	Food Based Dietary Guidelines
GMP	Growth Monitoring and Promotion
HSRC	Human Sciences Research Council
ICRC	International Committee of the Red Cross
IDA	Iron Deficiency Anaemia
IDD	Iodine Deficiency Disorders
IFPRI	International Food Policy Research Institute
IFSNP	Integrated Food Security and Nutrition Programme
IFSS	Integrated Food Security Strategy
IMCI	Integrated Management of Childhood Illnesses
IMF	International Monetary Fund
INP	Integrated Nutrition Programme
IWMI	International Water Management Institute
kcal	Kilocalories
kJ	Kilojoules
L	Litre
LBW	Low Birth Weight
LDC	Least Developed Countries
MDG	Millennium Development Goals
mo	Month(s)
NFCS	National Food Consumption Survey
NFCS-BF	National Food Consumption Survey – Baseline Fortification
NWP	Nutritional water productivity
OECD	Organisation for Economic Co-operation and Development
PHC	Primary Health Care

ppm	Parts per million
RDA	Recommended Dietary Allowances
SABS	South African Bureau of Standards
SADHS	South African Demographic and Health Survey
SAHR	South African Health Review
SAVACG	South African Vitamin A Consultative Group
SCN	Standing Committee in Nutrition
SD	Standard Deviation
SIWI	Stockholm International Water Institute
UN	United Nations
UNICEF	United Nation Children's Fund
VAD	Vitamin A deficiency
WB	World Bank
WHO	World Health Organization
WRC	Water Research Commission
y	Year(s)
yrs	Years

GLOSSARY OF CORE TERMINOLOGY

Anthropometry	The study and measurement of human body size and proportions.
Bioavailability	The amount of a nutrient ingested that is available for normal physiological functions and storage in the body.
Body mass index (BMI)	Weight to height ratio; expressed as body weight in kg divided by height in m^2.
Dietary diversity	The number of food items or food groups eaten.
Empowerment	Enhancing people's capacity to control their own lives by defining, analysing and acting upon their health and nutritional problems to their own satisfaction (Singleton, 1994).
Fluoride	Any binary compound of fluorine (F); fluoridation refers to the treatment with fluoride, e.g. the addition of fluorides to a public water supply as a public health measure to reduce the incidence of dental caries.
Food (supplementation) programmes	The provision of free or cheap food to people in need, either as full rations to everybody (blanket feeding), supplementary/complementary (top-up-) feeding of vulnerable groups, or therapeutic/treatment feeding; also called group feeding schemes/programmes or food aid.
Food fortification	Addition of nutrient(s) to a food during manufacture.
Goitrogens	Substances in food that can block the absorption or utilisation of iodine and thus reduce its uptake into the thyroid gland. Examples include vegetables of the Brassicaceae family (Gibson, 2005:752).
Household food insecurity	The inability to acquire or consume an adequate quality or sufficient quantity of food in socially acceptable ways, or the uncertainty that one will be able to do so (ADA, 2003).
Household food security	Access at all times by all people to safe, nutritious, and culturally appropriate food that is adequate for an active and healthy life, and that is obtained in a socially acceptable manner. It includes a supply dimension, which refers to nutritional adequacy, safety and cultural/social acceptability, as well as a stability dimension, which refers to ecological, economical and social sustainability. Sometimes a human rights dimension is added, which covers the access aspect (modified from ADA Position, 2003).
Hunger	A condition in which people lack the basic food intake to provide them with the energy and nutrients for fully productive, active lives (ADA Position, 2003). <u>Acute hunger</u>: Starvation that typically occurs during famines and disasters. This form of hunger represents about 10% of the world's hungry. <u>Chronic hunger</u>: Constant or recurrent lack of access to food of sufficient quality and quantity, good healthcare, and necessary caring practices. Most of the world's hungry (about 90%) fall in his category. In the case of children this results in underweight and stunting. <u>Hidden hunger</u>: Lack of essential micronutrients; afflicts more than 2 billion, even if they consume enough energy and protein (Sanchez et al., 2005).
Malnutrition	"Intake-related malnutrition" = Failure to achieve nutrient requirements, which can impair physical and/or mental health. It may result from consuming too little food, or a shortage or imbalance of key nutrients (e.g. micronutrient deficiencies or excess consumption of refined carbohydrates and fat) (ADA Position, 2003). "Disease-related malnutrition" = A state of nutrition in which a deficiency or excess or imbalance of energy, protein and other nutrients, causes measurable adverse effects on tissue or body form (body shape, size and composition), function, and clinical outcome (Stratton et al., 2003:3).

Micronutrient supplementation	Micronutrients taken in the form of pills, capsules, powders or syrups.
Millennium Development Goals (MDG)	Goals by the UN, IMF, OECD and WB, which spell out the right to development for everyone (see chapter 1).
Morbidity	The condition of being diseased or morbid; the sick rate (ratio of sick to well persons in a population).
Mortality	Death rate; ratio of actual death to expected deaths.
Nutrition security	The provision of an environment that encourages and motivates society to make food choices consistent with short- and long-term health. It includes food security, care and health promotion (ADA Position, 2002).
Obesity	Excess body fat: in adults it is usually defined as a body mass index ≥ 30 kg/m^2.
Osmolality	A measure of the osmotically active particles per kg of solvent in which the particles are dispersed. It is expressed as milliosmoles of solute per kg (mOsm/kg). Serum osmolality = (serum Na [mEq/L] x 2) + glucose (mg/dL)/18 + BUN (mg/dL)/2.8 (Mahan & Escott-Stump, 2004:168).
Overweight	Body weight exceeding the healthy limit; in adults usually defined as a body mass index > 25 kg/m^2 but < 30 kg/m^2.
Primary Health Care (PHC)	Essential health care based on practical, scientifically acceptable methods and technology which are universally available for individuals and groups in a community, and includes • basic education • nutrition and adequate food • safe water and sanitation • mother and child care • family planning • immunisation and prevention of endemic diseases • treatment of common diseases and injuries • provision of essentials drugs
Stunting	Linear growth retardation expressed in terms of low length / height for age.
Sustainability	Society's ability to shape its economic and social systems in order to maintain both natural resources and human life. Sustainable development includes the reduction of poverty and hunger in environmentally sound ways.
Underweight	In the case of infants and children: low weight for age In the case of adults: body mass index <18.5 kg/m^2.
Wasting	In the case of infants and children: low weight for length / height, or low body mass index for age In the case of adults: body mass index <16 kg/m^2.
Water footprint	Total volume of fresh water, both green (i.e. moisture in the soil) and blue (i.e. water-associated irrigation from aquifers, rivers and lakes) that is used to produce the goods and services consumed by the people of the nation, i.e. both food and other goods and services (SIWI IFPRI IUCN IWMI, 2005:21).
Xerophthalmia	Xerophthalmia collectively refers to all eye defects due to vitamin A deficiency.
Z-score	The deviation of the anthropometric measurement from the median of the reference population in terms of standard deviations.

CHAPTER 1
PERSPECTIVE

INTRODUCTION

Globally enough food is produced to meet the basic food needs of the world's inhabitants (Smith *et al.*, 2000). Yet 20% of the world population (i.e. over 840 million people, primarily from developing countries) suffer from chronic undernourishment (FAO, 1996 cited in Smith *et al.*, 2000) and even more are affected by micronutrient deficiencies or dietary imbalances.

This introductory chapter of the literature review on the nutritional status of South Africans, and some of the causes for nutritional deficiencies, presents a global perspective on the topic of malnutrition, contextualised for the South African setting. The aim is to state the principles, i.e. the Millennium Development Goals (MDGs) and South African national nutrition-related goals and targets, sustainability and a human rights perspective, that form the foundation of the review. Furthermore, the UNICEF conceptual framework of causes of malnutrition, which acts as golden thread throughout the report, is discussed.

1.1 MILLENNIUM DEVELOPMENT GOALS

In September 2000, 147 heads of State and Government (representing a total of 189 nations, including South Africa) committed themselves in the United Nations (UN) Millennium Declaration [A/RES/55/2] to make the right to development a reality for everyone and to free the entire human race from want. Eight Millennium Development Goals (MDGs) and 18 targets (see table 1.1) were consequently adopted in a consensus-decision by experts from the UN Secretariat as well as the International Monetary Fund (IMF), the Organisation for Economic Co-operation and Development (OECD) and the World Bank (WB).

Most of the MDGs, but in particular goals number one and four, have a clear relationship to the major problems regarding poor nutritional status in South Africa as described in chapter 2 of this review. Achievement of target two of MDGs number one logically leads to nutritional interventions, including a link between nutrition and agriculture. In addition, the targets under MDGs number seven refer to aspects of environmental sustainability relevant to this report (see section 1.2).

With a view to achieving the MDGs in order to eradicate extreme poverty and hunger, an international Task Force on Hunger has been established. This Task Force released a report "Halving hunger: it can be done" (Sanchez *et al.*, 2005). The report hinges on a strategic approach for reducing by half the prevalence of hunger, and has made seven recommendations for achieving this (table 1.2).

Recommendations three to seven in table 1.2 all refer to community level (as opposed to national, macro-level) interventions (Sanchez *et al.*, 2005). Some of the recommendations (two, three, four and seven) have direct content relevance to this review. Interventions that are proposed under these recommendations and that are relevant to this report are listed (and indented) in the table.

In 2004 a whole edition of the UN Standing Committee on Nutrition (SCN) News was devoted to analysing and describing links between the MDGs and nutrition (SCN, 2004). The proceedings of a symposium, "*Nutrition as key to achieving the millennium development goals*", are presented in this publication, focusing on the role of nutrition in accelerating improvements in poverty reduction, sustainable development and health, particularly amongst women and children.

TABLE 1.1: THE MILLENNIUM DEVELOPMENT GOALS

Goals	Targets
1. Eradicate extreme poverty and hunger	1. Reduce by half (between 1990 and 2015) the proportion of people living on less than a dollar a day 2. Reduce by half (between 1990 and 2015) the proportion of people who suffer from hunger
2. Achieve universal primary education	3. Ensure that, by 2015, all boys and girls complete a full course of primary schooling
3. Promote gender equality and empower women	4. Eliminate gender disparity in primary and secondary education, preferably by 2005, and at all levels by 2015
4. Reduce child mortality	5. Reduce by two thirds (between 1990 and 2015) the mortality rate among children under five
5. Improve maternal health	6. Reduce by three quarters (between 1990 and 2015) the maternal mortality ratio
6. Combat HIV/AIDS, malaria, and other diseases	7. Halt (by 2015) and begin to reverse the spread of HIV/AIDS 8. Halt (by 2015) and begin to reverse the incidence of malaria and other major diseases
7. Ensure environmental sustainability	9. Integrate the principles of sustainable development into country policies and programmes; reverse loss of environmental resources 10. Reduce (by 2015) by half the proportion of people without sustainable access to safe drinking water 11. Achieve (by 2020) significant improvement in lives of at least 100 million slum dwellers
8. Develop a global partnership for development	12. Develop further an open trading and financial system that is rule-based, predictable and non-discriminatory; includes a commitment to good governance, development and poverty reduction— nationally and internationally 13. Address the least developed countries' special needs. This includes tariff- and quota-free access for their exports; enhanced debt relief for heavily indebted poor countries; cancellation of official bilateral debt, and more generous official development assistance for countries committed to poverty reduction 14. Address the special needs of landlocked and small-island developing states 15. Deal comprehensively with developing countries' debt problems through national and international measures to make debt sustainable in the long term 16. In cooperation with the developing countries; develop decent and productive work for youth 17. In cooperation with pharmaceutical companies, provide access to affordable essential drugs in developing countries 18. In cooperation with the private sector, make available the benefits of new technologies— especially information and communications technologies

Source: http://www.un.org/millenniumgoals/index.html, accessed 28 November 2005

TABLE 1.2: RECOMMENDATIONS FOR HALVING HUNGER

1. Move from political commitment to action
2. Reform policies and create an enabling environment
   - link nutritional and agricultural interventions
   - strengthen agricultural and nutritional research
3. Increase agricultural productivity of food-insecure farmers
   - improve and expand small-scale water management
   - improve access to better seeds and other planting materials
   - diversify on-farm enterprises with high-value products
   - establish effective agricultural extension services
4. Improve nutrition for the chronically hungry and vulnerable
   - promote mother and infant nutrition
   - reduce malnutrition among children under age five, school-age children and adolescents, including micronutrient deficiencies and infections contributing to malnutrition
5. Reduce the vulnerability of the acutely hungry through productive safety nets
6. Increase incomes and make markets work for the poor
7. Restore and conserve the natural resources essential for food security
   - a "uniquely African Green Revolution in the twenty-first century" that capitalizes on existing knowledge to transform the region's agriculture, nutrition and markets

Source: Sanchez *et al.*, 2005

1.1.1 National food and nutrition-related goals and programmes in South Africa

According to the British Department for International Development (DFID) (http://www.dfid.gov.uk/countries/africa/southafrica.asp, accessed 21 August 2006) South Africa is well on course to meet all the MDGs well ahead of the 2015 deadline. In respect of those MDGs specifically relevant to this review (see above), the South African government has established a number of national programmes, most of which fall in the so-called Social Cluster (South Africa Yearbook, 2005/06).

Income poverty alleviation is addressed by social income grants. These reached 10 million people in 2005, compared to 2.6 million in 1994. The Expanded Public Works Programme (EPWP), the Agriculture Starter Pack Programme and the Comprehensive Agricultural Support Programme (CASP) are additional examples of national programmes aimed at increasing jobs, skills and food production.

Asset poverty alleviation focuses on housing, land, water and sanitation, and electrification. Of specific relevance to this review is that by March 2005, 31.9 million South Africans had access to free basic water, i.e. ten million more than in 1994.

Human capital poverty alleviation addresses healthcare and education. Healthcare has been reformed to focus on the provision of primary health care (PHC), which includes free healthcare for pregnant and lactating women and children <6 y and an Expanded Programme on Immunisation (EPI) (South Africa Yearbook, 2005/06).

Specifically in the field of nutrition, major national and smaller-scale programmes have been initiated in the last decade. Within the Department of Health, the Integrated Nutrition Programme (INP) was initiated in 1995. It aims to ensure optimum nutrition for all South Africans by preventing and managing malnutrition, and includes the following:

- disease-specific nutritional support, treatment and counselling
- growth monitoring and promotion (GMP)
- nutrition promotion
- micronutrient malnutrition control
- food-service management
- promotion, protection and support of breastfeeding
- contributions to household food security

In September 2002 the Department of Health set objectives for each of the focus areas of the INP. The objective within the focus area of micronutrient malnutrition is the elimination of micronutrient deficiencies. The specific targets to be reached by 2007 refer to a prevalence of 19% for vitamin A deficiency, 7.5% for iron deficiency and 5% for iodine deficiency. For the objective to decrease malnutrition in children <5 y, the measurable targets to be achieved by 2007 include figures of 8% underweight, 18% stunting and 2% wasting. With regard to the nutritional status of female adults, the specific targets to be reached by 2007 refer to rates of 20% overweight and 25% obesity (Labadarios *et al.*, 2005).

Another landmark development was Cabinet's approval of the Integrated Food Security and Nutrition Programme (IFSNP) in July 2002 as one of the key programmes of the Social Cluster. Its goal is to eradicate hunger, malnutrition and food insecurity in 2015 (South African Yearbook, 2005/06:88), in accordance with the international MDG. The Department of Social Development's National Food Emergency Scheme forms part of the IFSNP and is a temporary measure by means of which food parcels are distributed to the most vulnerable sections of the population (South Africa Yearbook, 2005/06:544).

The National School Nutrition Programme (formerly the Primary School Nutrition Programme) is primarily concerned with school feeding, and has been transferred from the Department of Health to the Department of Education in an attempt to expand its impact by creating employment opportunities for women, establishing community-based food gardens and integrating nutrition into the curriculum (South Africa Yearbook, 2005/06:399, 545).

1.1.2 South African intervention strategies

Strategies and approaches to address malnutrition can be either supply- or demand-driven. In supply-driven approaches providers of food or nutrition programmes implement decisions and the consumer more or less passively "receives" these, whereas in the demand-driven approaches the focus is on the empowerment of the consumer to make informed choices.

In the case of micronutrient deficiencies the major interventions include food fortification (addition of micronutrients to foods during manufacture), supplementation (provision of one or more micronutrients in tablet, powder or liquid form), nutrition education (dietary diversification) and a food-based (e.g. gardening) approach. For the short-term alleviation of hunger, provision of food (food supplementation) in various forms, ranging from blanket feeding to complementary feeding and "work for food" are strategies that can be applied.

1.1.2.1 The national food fortification programme

Food fortification is the approach often sought by developing countries to address micronutrient deficiencies. This option bypasses the lack of health infrastructure needed to deliver supplementation. The South African National Food Consumption Survey (NFCS) identified the most commonly eaten foods among children in this country. According to this survey maize, white sugar, tea, whole milk and brown bread were foods most commonly eaten by 1-9-y-old children (Labadarios *et al.*, 2000). Therefore these foods seem the most appropriate vehicles for fortification. The report recommended that vitamin A, iron and zinc should be included in a national fortification programme.

Fortification of maize and wheat flour was legislated in October 2003. Maize and wheat flour are fortified to provide a person of 10 y or older with vitamin A (31%), thiamine (25%), niacin (25%), pyridoxine (25%), folate (50%), riboflavin (17% from maize and 20% from wheat), iron (25% from unsifted maize meal and 50% from maize meal), and zinc (20%) of the recommended dietary allowance (RDA) per 200g of raw meal/wheaten flour (Labadarios *et al.*, 2005).

Mandatory iodization of table salt was introduced in 1995 in order to prevent and address iodine deficiency.

1.1.2.2 Vitamin A supplementation programme

Supplementation is considered a short-term strategy to address micronutrient deficiencies. The South African vitamin A supplementation programme forms part of the routine immunization program (i.e. the EPI), maternal health, and the Integrated Management of Childhood Illnesses (IMCI).

1.1.2.3 Unmet needs: The gap between what is and what should be

The above-mentioned successes and the numerous programmes that are in place should not lead to complacency. Chapter 2 of this review shows that the absolute numbers of people still affected by malnutrition, the remaining proportion (i.e. after halving the 1990 prevalence as stipulated in the MDGs) and the unequal distribution of malnutrition are unacceptable. Despite government's attempts at redirecting spending toward the poor, South Africa remains a highly unequal society experiencing "two economies" – a vibrant first world economy and the much larger informal rural and urban economy in which deprivation is commonplace. A huge proportion of South Africans (about 35%) are still very poor, unemployed or jobless, contributing to widespread food insecurity (see chapter 3). Linked to the problem of poverty is the fact that South Africa has one of the highest HIV/AIDS prevalence rates in the world, with an estimated number of people infected with HIV of 5.6 million, of which 3.1 million are women (DFID, http://www.dfid.gov.uk/countries/africa/southafrica.asp, accessed 21 August 2006; South Africa Yearbook, 2005/06).

The unequal distribution of the burden of morbidity is reflected in the wide ranges in the prevalence rates of the various indicators of socio-economic and health-related status across the nine provinces of South Africa (South African Health Review 2001, 2002). Differences in a so-called Index of Multiple Deprivation consisting of income, employment, health, education and living environment were also shown within the provinces (Noble *et al.*, 2006).

1.2 SUSTAINABLE DEVELOPMENT

Ever since the Report of the UN Conference on the Human Environment in Stockholm 1972 (reaffirmed in Rio de Janeiro, 1992, and in Johannesburg, 2002) the concept of sustainable development has become a yardstick by which global interventions, including nutrition-related actions, are judged.

Sustainability is formally defined as "society's ability to shape its economic and social systems so as to maintain both natural resources and human life" (ADA Position, 2003). Sustainable development includes the reduction of poverty and hunger in environmentally sound ways. It also embraces the following broader objectives that are interrelated and mutually reinforcing (ADA Position, 2003):

- expanding economic opportunities, especially for poor people, to increase their productivity, earning capacity, and chances to earn income in ways that are environmentally, economically and socially viable in the long term
- meeting basic human needs for food, clean water, shelter, education, and fulfilment of the human spirit
- protecting and enhancing the natural environment by managing natural resources in ways that take into account the needs of present and future generations
- promoting pluralism and democratic participation, especially by poor women and men, in economic and political decisions that affect their lives, with full respect for internationally recognised human rights.

Interventions that address malnutrition within the context of the MDGs should be expected to meet the requirements spelled out by sustainable development. This means that each of the three symbols of the definition of sustainable development - "planet, people and poverty"- used during the Johannesburg Conference on Sustainable Development (reflecting environmental, human and financial aspects respectively), should be kept in mind by nutrition programmes.

1.3 NUTRITION AS A HUMAN RIGHT IN SOUTH AFRICA

South Africa has a uniquely nutrition-friendly constitution. In paragraph 27 in the Bill of Rights (The Constitution of the Republic of South Africa Act 108 of 1996) health care, food, water and social security are stipulated. It specifies:

"1. Everybody has the right to have access to
   - *a) health care services, including reproductive health care;*
   - *b)* ***sufficient food and water****; and*
   - *c) social security, including if they are unable to support themselves and their dependants, appropriate social assistance.*

2. The state must take reasonable legislative and other measures, within its available resources, to achieve the progressive realisation of these rights.

3. No one may be refused emergence medical treatment."

The above, plus the UNICEF Convention on the Rights of the Child (1990) as officially ratified by South Africa, form the preamble of the South African national nutrition policy as outlined in the INP.

1.4 PREVENTING MALNUTRITION BY ADDRESSING ITS CAUSES

Adequate dietary intake is an essential condition for good nutrition. It may, however, not be sufficient, because the presence of disease can result in reduced bioavailability or increased needs or nutrient losses, and can thus also be an immediate cause of malnutrition, leading to the so-called "disease-related" malnutrition (Stratton *et al.*, 2003:3). It follows that inadequate intake and/or disease can be the immediate causes of malnutrition.

To accommodate both inadequate dietary intake and disease as causes of malnutrition, the UNICEF conceptual framework has been widely adopted to describe the causes of malnutrition. This conceptual framework (figure 1.1) has been included by the Department of Health in the INP and guides national nutrition policy, which aims to combat malnutrition holistically by addressing the multitude of causes, rather than (only) treating the manifestation, i.e. malnutrition.

Apart from food (insufficient household food security) two additional inter-related underlying causes of malnutrition in children are highlighted in this framework, namely inadequate care on the one hand, and insufficient health services and an unhealthy environment on the other hand. The term nutritional *insecurity* has sometimes been used to encapsulate this broader view of causes of malnutrition on the individual level. Phrased positively, nutrition security is defined as "the provision of an environment that encourages and motivates society to make food choices consistent with short- and long-term health. It includes food security, care and health promotion" (ADA, 2002; see also chapter 3).

Using figure 1.1 as basis for approaching the problem of malnutrition means acknowledging that malnutrition has many causes. To achieve the MDGs and the national nutrition-related targets thus requires implementation of multi-sectoral (different types of interventions by different disciplines or departments, e.g. Health and Agriculture) and multi-level (directed at immediate, underlying and basic causes of the conceptual framework; figure 1.1) interventions. Our constitution declares this a human right of every South African, and sustainability considerations will ensure nutrition security for generations to come.

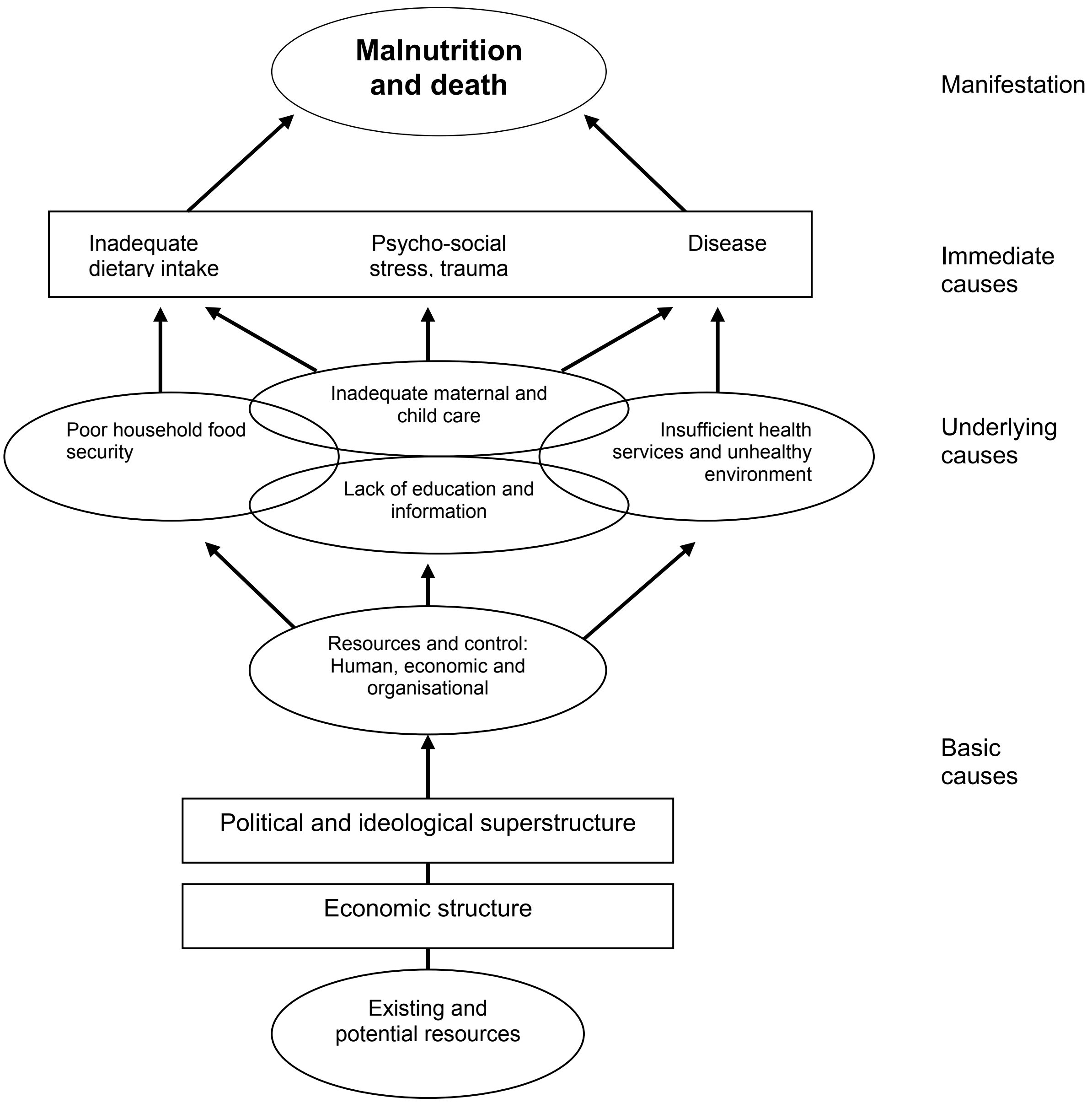
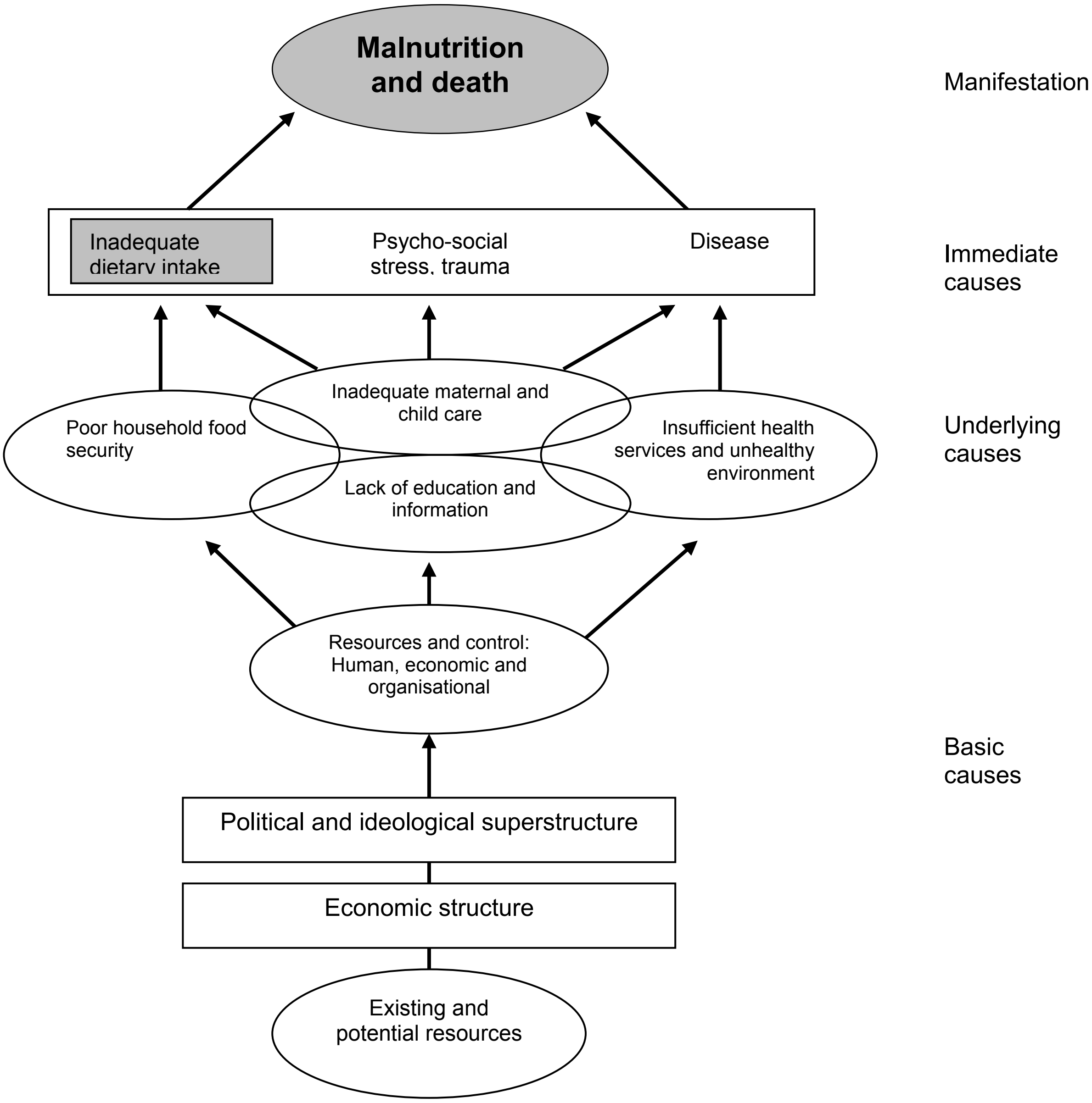


FIGURE 1.1: UNICEF CONCEPTUAL FRAMEWORK OF CAUSES OF MALNUTRITION AND DEATH IN CHILDREN, AS ADOPTED BY THE SOUTH AFRICAN DEPARTMENT OF HEALTH
Source: Department of Health, 1998

CHAPTER 2

NUTRITIONAL STATUS OF SOUTH AFRICANS



INTRODUCTION

It has been estimated that malnutrition is the underlying cause of more than half of child deaths (age 6-59 mo) in developing countries (Schroeder, 2001:404), including sub-Saharan Africa (Pelletier *et al.*, 1995). Of these deaths 83% are attributable to mild-to-moderate (rather than severe) under-nutrition (Schroeder, 2001:404).

South Africa has a quadruple burden of disease, namely (i) infectious diseases associated with under-development, poverty and under-nutrition; (ii) chronic diseases linked to over-nutrition and a western type of diet and lifestyle; (iii) the HIV/AIDS epidemic; and (iv) the burden of injury-related deaths (Steyn *et al.*, 2006a:34). Under- and over-nutrition co-exist, not only in South Africa as a whole, but sometimes within a household. Nutritional status is most commonly determined by anthropometric evaluations, biochemical markers of malnutrition and assessment of dietary intake. In this chapter, anthropometric status of children and adults, micronutrient malnutrition, and dietary intake of vulnerable groups within South Africa are discussed.

For each of these a general overview of the causes, consequences and indicators for assessment is given, followed by current prevalence figures for South Africa. The most significant contribution to national data on nutritional status of South Africans is from the South African Vitamin A Consultative Group (SAVACG) study that was done in 1994 (Labadarios *et al.*, 1995) and the NFCS that was done in 1999 (Labadarios *et al.*, 2000). The results of the National Food Consumption Survey – Fortification Baseline (NFCS-FB) that was done in January 2005 were not yet released at the time when this report was finalised. National data will be supplemented with data from smaller studies published after 1996. Vorster *et al.* (1997) reviewed studies published between 1975 and 1996, and these studies will therefore not be included in this review, but the report by Vorster *et al.* (1997) will be referred to. The purpose of this chapter is not to exhaust all nutritional studies published after 1996, but to give a general overview of the nutritional status of South Africans, focusing on the major nutritional problems and the most vulnerable groups.

2.1 ANTHROPOMETRIC STATUS OF CHILDREN

2.1.1 Anthropometric measurements

Anthropometry is a simple non-invasive approach to determine nutritional status of children and adults. In children three indices of malnutrition are usually computed, namely height-for-age, weight-for-age and weight-for-height. Each of these indices is expressed as z-scores or standard deviations (SD) of the median of the reference population. Children with height-for-age, weight-for-age and weight-for-height z-scores more than 2 SD below the reference median are classified as stunted, underweight and wasted, respectively (Cogill, 2003:41).

Stunting is a measure of linear growth retardation and an indicator of chronic malnutrition. Its onset is often associated with the age of the introduction of complementary feeding (Brown *et al.*, 1995). Stunting is associated with a number of long-term factors such as chronic insufficient protein and energy intake, frequent infections, sustained inappropriate feeding practices and certain micronutrient deficiencies, particularly iron and zinc (Cogill, 2003:11). Stunting is associated with poverty (Cogill, 2003:11) and poor socio-economic conditions (Gorstein *et al.*, 1994). Because stunting has a socio-economic dimension, it should be viewed in a broader context and not merely in a narrow biomedical sense (Zere & McIntyre, 2003). Stunting does not change rapidly, and it may be irreversible in children above 2 y of age (Cogill, 2003:11). Stunted children have multiple functional disadvantages that persist throughout childhood, such as deficits in cognitive development, behaviour and school achievement (Chang *et al.*, 2002; Mendez & Adair, 1999). Stunted children are also at a higher risk of morbidity and often have impaired immune function (Pelletier, 1994; Chandra, 1991).

Underweight is a measure of both chronic and acute malnutrition, although it cannot distinguish between the two.

Wasting is a measure of acute malnutrition. Causes include inadequate food intake, incorrect feeding practices, disease and infection, or more frequently, a combination of these factors (Cogill, 2003:11). Wasting in individual children and population groups can change rapidly with changes in the availability of food or disease prevalence.

The severity of stunting, underweight and wasting of children <5 y in a population can be determined using the WHO classification as shown in table 2.1.

TABLE 2.1: CLASSIFICATION FOR ASSESSING THE SEVERITY OF MALNUTRITION BY PREVALENCE RANGES AMONG CHILDREN UNDER 5 YEARS OF AGE

Indicator	Severity of malnutrition by prevalence ranges			
	Low	Medium	High	Very high
Stunting	<20	20-29	30-39	∃40
Underweight	<10	10-19	20-29	∃30
Wasting	<5	5-9	10-14	∃15

Source: Gorstein *et al.,* 1994

2.1.2 Anthropometric status

National anthropometric data are available for 6-71-mo-old children for 1994 (Labadarios *et al.*, 1995) and 1-9-y-old children for 1999 (Labadarios *et al.*, 2000) (see table 2.2). These two studies showed a low prevalence of wasting (<5%), a low (<10%) to medium (10-20%) prevalence of underweight, and a medium (20-29%) prevalence of stunting at the national level (see table 2.1 for classification). The problem therefore is chronic under-nutrition, rather than acute under-nutrition. Both the SAVACG study and the NFCS showed that prevalence figures differed between provinces, that children living on commercial farms were severely affected, and that the prevalence of malnutrition was higher in the rural areas compared with the urban areas. Secondary data analysis of the Living Standards and Development Survey of 1993 showed that children in the lowest socio-economic strata bear a greater burden of malnutrition (stunting and underweight, but not wasting), and that income-related inequalities in malnutrition were lowest in rural settings and highest in metropolitan areas (Zere & McIntyre, 2003).

TABLE 2.2: ANTHROPOMETRIC STATUS OF SOUTH AFRICAN CHILDREN NATIONALLY AND BY PROVINCE IN 1994 (SAVACG STUDY) AND 1999 (NFCS)

INDICATOR	Year	Age group	Eastern Cape	Free State	Gauteng	KwaZulu -Natal	Mpuma-langa	Northern Cape	Limpopo	North-West	Western Cape	RSA
	1994	6-71 mo	N=1 540	N=1 420	N=837	N=1 277	N=1 277	N=944	N=1 457	N=1 644	N=842	N=11 238
	1999	1-9 y	N=381	N=203	N=411	N=465	N=144	N=135	N=321	N=229	N=324	N=2 613
Stunting	1994	6-71 mo	28.8	28.7	11.5	15.6	20.4	22.8	34.2	24.7	11.6	22.9
HAZ < -2 SD	1999	1-9 y	20.5	29.6	20.4	18.5	26.4	29.6	23.1	24.9	14.5	21.6
		1-3 y	23.2	39.8	26.2	25.1	29.1	30.0	19.9	31.9	14.2	25.5
		4-6 y	19.9	27.2	15.6	16.8	25.0	31.3	29.0	18.3	14.8	20.7
		7-9 y	16.9	3.4	6.0	4.8	21.4	23.5	16.7	17.6	14.8	13.0
Underweight	1994	6-71 mo	11.4	13.6	5.6	4.2	7.3	15.6	12.6	13.2	7.0	9.3
WAZ < -2 SD	1999	1-9 y	7.1	14.3	8.8	6.0	4.2	23.7	15.0	15.3	8.3	10.3
		1-3 y	10.6	20.4	9.9	6.5	7.3	27.1	14.0	18.6	9.9	12.4
		4-6 y	3.8	9.9	9.4	6.6	3.3	20.8	16.0	12.2	4.9	8.8
		7-9 y	7.2	6.9	2.0	3.6	0.0	17.6	14.8	11.8	11.5	7.7
Wasting	1994	6-71 mo	3.2	4.5	1.2	0.7	1.7	2.5	3.8	4.5	1.3	2.6
WHZ < -2 SD	1999	1-9 y	1.8	3.4	1.2	4.3	2.8	9.6	7.5	5.7	0.9	3.7
		1-3 y	2.8	3.2	1.3	2.3	1.8	12.9	11.0	5.3	1.4	4.0
		4-6 y	1.9	1.2	1.6	5.4	3.3	4.2	5.3	7.3	0.8	3.4
		7-9 y	0.0	10.3	0.0	7.2	3.4	11.8	3.7	2.9	0.0	3.4
Overweight WHZ > 2 SD	1999	1 - 9 y	7.9	6.4	5.6	6.5	16.7	4.4	3.7	0.9	5.2	6.0

Sources: Labadarios *et al.*, 1995; 2000

Anthropometric status of children as reported in smaller studies is shown in table 2.3. Most of these studies were done on black children in rural areas, except for the studies by Oelofse *et al.* (2002), which was done on urban black (Kayamandi) and coloured (Cloetesville) infants and Sickle *et al.* (1998), which was done on urban children. As was the case in earlier studies (Vorster *et al.*, 1997:7), the data shows that the prevalence and severity of malnutrition differs from area to area, and that pockets of malnourished children exist. From table 2.3 it is clear that the prevalence of malnutrition (in terms of underweight and stunting) increases significantly from the first to the second year of life. Thereafter the prevalence of malnutrition remains fairly constant. The period 6-12 mo, in particular, carries a great risk of growth faltering and malnutrition because of the inadequate nutritional quality of complementary foods and the increased risk of infections due to the decline in breastfeeding.

TABLE 2.3: PREVALENCE OF STUNTING, UNDERWEIGHT AND WASTING FOR CHILDREN AS DETERMINED IN SMALLER STUDIES

Province	Age	N	Stunted	Under-weight	Wasted	Over-weight	Source
Eastern Cape	< 12 mo	236	11	2	2	16	Smuts *et al.*, 2004
O.R. Tambo	12-<24 mo	174	37	13	5	13	
	24-<60 mo	361	26	12	7	3	
Alfred Nzo	< 12 mo	168	14	5	4	21	
	12-<24 mo	189	22	11	4	11	
	24-<60 mo	404	33	12	2	6	
KwaZulu-Natal	< 12 mo	144	12	6	1	16	
Umkhanyakude	12-<24 mo	170	24	13	6	9	
	24-<60 mo	437	18	9	6	3	
Nongoma	< 12 mo	89	13	8	1	17	
	12-<24 mo	109	35	7	1	19	
	24-<60 mo	228	33	10	3	10	
Pongola	< 12 mo	57	14	5	2	16	
	12-<24 mo	106	18	6	3	8	
	24-<60 mo	270	18	8	2	4	
KwaZulu-Natal	6-11 mo	47	10.6	4.1	0		Oelofse *et al.*, 1999
	12-23 mo	96	19.8	8.2	4.1		
	24-59 mo	267	16.9	3.7	1.5		
	60-132 mo	336	20.4	3.3	0.9		
KwaZulu-Natal	6-11 yrs	228	12	1.7	0		Van Stuijvenberg *et al.*, 1999
KwaZulu-Natal	2-5 yrs	154	21	9	<1	3	Faber *et al.*, 2001
KwaZulu-Natal	4-24 mo	115	15.3	3.6	0.9	7.2	Faber & Benadé 1999
KwaZulu-Natal	6-12 mo	289	11.5	4	<1	23*	Faber *et al.*, 2005
KwaZulu-Natal Hlabisa	3-59 mo	868	26.3	12.0	1.3		Chopra, 2003
Limpopo	12 mo	156	34.6	10.9	2.6	12.3	Mamabolo *et al.*, 2004
Limpopo	3 yrs	162	48	9	1	18	Mamabolo *et al.*, 2005
Western Cape							
Kayamandi	6-12 mo	60	7	2	0		Oelofse *et al.*, 2002
Cloetesville	6-12 mo	60	18	8	0		
Western Cape Urban	6-11 yrs	228	8.3	5.7	3.5		Sickle *et al.*, 1998

*unpublished data

Secondary analysis of the NFCS data showed that child growth was associated with dietary diversity (Steyn *et al.*, 2006c). In Hlabisa, a rural area in KwaZulu-Natal, risk factors for stunting and underweight were reflective of maternal status and socio-economic status of the household (Chopra, 2003). Stunting and underweight, but not wasting, are responsive to improvements in the socio-economic status of the household (Zere & McIntyre, 2003). A community-based nutrition education programme in combination with food-aid resulted in improvements in weight-for-age and weight-for-height of 2-5-y-old children in the Free State and Northern Cape, but the programme failed to facilitate catch-up growth in stunted children. The authors recommended that socio-economic variables such as sanitation, housing, literacy and employment, be included in integrated interventions if the overall prevalence of stunting is to be decreased (Walsh *et al.,* 2002). It has also been suggested that initiatives to address the problem of growth failure should focus on improving the caring capacity of mothers (De Villiers & Senekal, 2002).

It is important to evaluate anthropometric status in terms of both stunting and overweight. Mamabolo *et al.* (2005) showed that 19% of 3-y-old children residing in the central region of Limpopo province were both stunted and overweight.

Studies in KwaZulu-Natal and the Eastern Cape showed that approximately 20% of infants (<12 mo) were overweight (table 2.3). In the NFCS 6% of 1-9-y-old South African children were overweight, and childhood obesity was higher in urban areas, particularly for children of well-educated mothers (Labadarios *et al.*, 2000).

In the early 1990s Cameron *et al.* (1994) reported that rural black girls showed a rapid weight gain in fatness after peak height velocity, and they hypothesized that the fat gain may be a physiological adaptation to an environment of suboptimal energy availability to buffer the energy cost of reproduction. Secondary analysis of the NFCS data showed that stunting was associated with an increased risk of being overweight (Steyn *et al.*, 2005). A study by Kruger *et al.* (2004) showed that stunted girls seem to be at risk of relatively greater fat deposition, especially in the abdominal area.

2.2 ANTHROPOMETRIC STATUS OF ADULTS

Anthropometric measurements expressed as body mass index (BMI) provide a good reflection of the nutritional status of adults.

$$BMI = \frac{weight\ (kg)}{height\,(m)^2}$$

WHO (1998) defined underweight as BMI<18.5; normal weight as 18.5≤BMI<25; overweight as 25≤BMI<30; and obesity as BMI≥30.

The results of the Demographic and Health Survey (DHS) of 2003 were not yet released at the time of finalizing this report. Therefore, the anthropometric status of adults as determined by the DHS of 1998 is given in table 2.4 (men) and table 2.5 (women).

TABLE 2.4: THE PERCENTAGE OF MEN AGED 15 YEARS AND ABOVE BY BODY MASS INDEX (BMI) CATEGORIES TO BACKGROUND CHARACTERISTICS, SOUTH AFRICA 1998

Background characteristic	Underweight BMI<18.5	Normal weight BMI: 18.5–24.9	Overweight BMI: 25–29.9	Obese BMI: 30+	Number
Age					
15-24	21.3	67.5	8.4	2.7	1 796
25-34	8.5	62.9	20.7	7.8	1 103
35-44	8.5	52.8	24.9	12.8	990
45-55	9.2	45.2	28.1	17.3	678
55-64	9.1	47.5	28.3	14.4	510
65+	9.9	47.7	28.5	13.9	482
Residence					
Urban	10.8	55.5	22.2	11.1	3 486
Non-urban	16.4	61.4	15.6	6.3	2 072
Province					
Eastern Cape	11.5	57.6	20.5	10.1	750
Free State	18.8	56.7	16.3	8.1	439
Gauteng	9.7	58.5	21.1	10.2	1 060
KwaZulu-Natal	11.1	56.8	21.4	10.4	1 047
Limpopo	19.7	57.9	16.0	6.2	505
Mpumalanga	16.9	59.1	16.6	7.5	366
Northern Cape	23.1	54.3	14.4	7.6	132
North-West	17.5	61.4	15.4	5.5	544
Western Cape	5.8	55.3	25.3	13.1	706
Education					
None	12.2	58.3	21.3	8.2	549
Sub A – Std 3	14.6	58.3	18.4	8.2	760
Std 4 – Std 5	15.9	58.5	17.6	7.4	745
Std 6 – Std 9	15.0	59.8	17.2	7.6	2 256
Std 10	5.6	58.7	22.2	13.4	785
Higher	7.1	41.6	33.5	17.8	430
Population group					
African	14.0	60.8	17.1	7.8	4 191
African urban	11.8	59.4	18.8	9.6	2 329
African non-urban	16.7	62.6	15.0	5.5	1 862
Coloured	11.4	56.6	22.1	9.2	628
White	4.7	38.1	36.1	20.8	536
Asian	16.6	50.7	23.7	9.0	189
Total	12.9	57.7	19.8	9.3	5 558

Source: SADHS, 1998:246

TABLE 2.5: THE PERCENTAGE OF WOMEN AGED 15 YEARS AND ABOVE BY BODY MASS INDEX (BMI) CATEGORIES TO BACKGROUND CHARACTERISTICS, SOUTH AFRICA 1998

Background characteristic	Underweight BMI<18.5	Normal weight BMI: 18.5–24.9	Overweight BMI: 25–29.9	Obese BMI: 30+	Number
Age					
15-24	9.5	60.7	20.0	9.6	2 044
25-34	5.1	38.4	29.2	27.0	1 679
35-44	2.7	27.2	30.7	39.3	1 436
45-55	3.7	23.9	26.5	45.5	1 087
55-64	2.7	25.6	25.6	46.1	895
65+	7.4	32.5	26.5	33.3	829
Residence					
Urban	5.0	35.6	26.0	33.2	4 886
Non-urban	6.5	41.9	26.2	25.1	3 084
Province					
Eastern Cape	5.8	38.8	25.7	29.7	1 130
Free State	7.0	37.9	26.0	29.2	517
Gauteng	3.4	34.3	26.6	35.6	1 842
KwaZulu-Natal	5.4	31.2	27.4	35.4	1 554
Limpopo	7.2	48.7	24.0	20.1	831
Mpumalanga	4.9	43.8	24.9	25.8	500
Northern Cape	12.5	37.5	24.9	24.8	166
North-West	8.1	46.8	25.8	18.9	642
Western Cape	4.9	37.8	25.9	31.2	788
Education					
None	5.8	34.4	27.2	32.6	1 166
Sub A – Std 3	6.4	32.3	25.2	36.0	1 055
Std 4 – Std 5	4.8	33.4	28.1	33.2	1 102
Std 6 – Std 9	5.6	41.2	24.3	28.7	3 039
Std 10	6.3	38.8	30.0	24.8	1 096
Higher	4.1	49.1	23.3	23.3	477
Population group					
African	4.9	37.7	25.9	31.2	6 143
African urban	3.9	34.0	25.5	36.3	3 293
African non-urban	6.0	42.0	26.5	25.3	2 850
Coloured	9.9	36.1	25.3	28.5	800
White	2.9	44.2	27.4	25.5	731
Asian	15.6	35.8	27.3	21.3	284
Total	5.6	38.1	26.1	30.1	7 970

Source: SADHS, 1998:247

Over-nutrition is prevalent among South Africans, particularly women, with 56.2% at national level being either overweight or obese. Smaller studies have shown pockets of severe female overweight/obesity. For example, in a rural area in KwaZulu-Natal 76.9% of the females were either overweight or obese (Oelofse *et al.,* 1999).

Determinants of overweight and obesity in South Africa include age, level of education, ethnicity, and area of residence (Puoane *et al.,* 2002). The prevalence of obesity is higher in urban areas than in rural areas (SADHS, 1998). With the present rapid urbanization the prevalence of obesity in adults is expected to increase (Vorster *et al.,* 2000). According to Steyn *et al.* (2006a:5), the high prevalence of overweight and obesity in the adult population reflects the westernised eating pattern that is followed by the white, coloured and Indian populations. They further state that the black population is undergoing a transition from a traditional high-fibre, high-carbohydrate intake to a more typically western diet. Bourne *et al.* (2002) summarised dietary data from urban and rural studies from 1940 to 1992 and concluded that the diets of the black South African population shifted towards an atherogenic western diet.

The black population constitutes 76.7% of the South Africa population (Statistics South Africa, 2000), and 57.1% of black females are either overweight or obese (SADHS, 1998:247). The acceptance of overweight and obesity in the black population could make it difficult to prevent or treat obesity. It has been reported that in the black South African population obesity has no negative social connotations (Mvo *et al.,* 1999), most women are unconcerned about their weight (Faber & Kruger, 2005), few women perceive themselves as being obese (SADHS, 1998:240) and they do not want to lose weight (Kruger *et al.,* 1994; Faber & Kruger, 2005). Fatness has been associated with wealth and prosperity in an earlier study (Chesler, 1961) and more recently with affluence and happiness (Mvo *et al.,* 1999). The treatment and control of obesity in South Africa is further hampered by the high prevalence of obesity amongst health workers (Puoane *et al.,* 2005). Senekal *et al.* (2003) suggested that specific ethnic characteristics, such as obesity-tolerant attitudes, should be taken into consideration when developing weight control programmes.

2.3 MICRONUTRIENT MALNUTRITION

Micronutrient malnutrition is referred to as “hidden hunger”, as the consequences thereof often go unnoticed. Three micronutrient deficiencies have captured most of the world’s attention in the last decade, namely, vitamin A deficiency (VAD), iron deficiency anaemia and iodine deficiency disorders (IDD). Zinc deficiency has also recently come to the forefront. Poor and underprivileged children in developing countries are at particular risk of these nutritional deficiencies.

2.3.1 Vitamin A deficiency

Vitamin A is an essential micronutrient needed for maintaining vision and eye health, integrity of epithelial cells, embryonic development, and maintenance of the immune system (Gibson, 2005:477).

The term VAD includes both clinical and sub-clinical VAD. Indicators for clinical VAD are signs of xerophthalmia, while sub-clinical VAD refers to situations where tissue levels of vitamin A are low enough to have adverse health consequences, even if there is no evidence of clinical xerophthalmia (WHO, 1996:2-3).

2.3.1.1 Causes

VAD is caused by a habitual diet providing too little bioavailable vitamin A to meet physiological needs (Underwood, 2000). Vitamin A from foods of animal origin, for example dairy products, liver and egg yolks, is in the form of preformed vitamin A, which is the most bioavailable dietary source of vitamin A. Foods of animal origin are often out of the financial reach of resource- poor households, and many households rely on yellow/orange-fleshed vegetables, dark-green leafy vegetables and yellow/orange-fleshed non-citrus fruit as their main source of vitamin A. Estimates suggest that more than 80% of dietary intakes of vitamin A in Africa are from plant foods (WHO, 1995). Vitamin A in plant foods is in the form of provitamin A carotenoids, predominantly β-carotene. Provitamin A carotenoids in vegetables and fruit achieve vitamin A activity when they are converted to retinol in the body. Several factors influence the bioavailability and bioconversion of provitamin A carotenoids (Castenmiller & West, 1998; De Pee & West, 1996). These include the food matrix, size of the food particles eaten, food preparation methods that disrupt the food matrix to different degrees, the presence of fibre (inhibits carotenoid absorption), dietary fat (enhances absorption) and bile salts and pancreatic enzymes in the intestinal lumen (enhance digestion), and the nutritional status of the individual. The food matrix and the presence of dietary fat are of particular importance.

Rapid growth and frequent infections, which cause ineffective utilisation of the vitamin, are also critical factors for VAD (Underwood, 2000).

Population groups vulnerable for VAD are listed below (Ahmed & Darnton-Hill, 2004:200-203).

- Children under 5 y are the most vulnerable because of a combination of factors such as rapid growth, infections and low vitamin A status at birth.
- Boys tend to have a higher prevalence of VAD.
- Pregnant and lactating women have increased vitamin A requirements.
- Children with measles, acute or prolonged diarrhoea, acute lower respiratory infection, and severe protein-energy-malnutrition are more likely to develop VAD.
- Children living under poor socio-economic conditions are particularly vulnerable to VAD.
- Non-breastfeeding infants are more likely to develop VAD.

2.3.1.2 Consequences

The clinical and pathological features associated with VAD are summarised below.

- *Eye-related problems.* Xerophthalmia collectively refers to all ocular manifestations of VAD. The earliest eye-related sign of VAD is night blindness, which means difficulty or inability to see in dim light such as during dusk or at night. This can progress to structural eye damage such as conjunctival xerosis (dryness of the membranes) and Bitot's spots (foamy white patches), followed by corneal xerosis (dryness of the cornea) and, in severe cases, keratomalacia (softening of the cornea). This may eventually result in impairment of vision or irreversible blindness (E-Siong 1995).
- *Loss of appetite and poor child growth* (Gibson, 2005:478).
- *Impaired immune response with lowered resistance to infection* (Gibson, 2005:478)
- *Higher mortality rate in children.* Children who are vitamin A deficient are more likely to die than well-nourished children. Of the estimated 125 million preschool children who are vitamin A deficient, approximately 1 to 2.5 million die annually as a consequence (ACC/SCN, 2000). Improving vitamin A status of young children can reduce the mortality rate by 23% in vitamin A

deficient populations (Beaton *et al.*, 1993). In the report by Steyn *et al.* (2006a:23) it is mentioned that an estimated 3 000 deaths in 0-4-y-old children due to diarrhoea were attributed to VAD in South Africa in 2000.

- *Higher mortality rate in women of reproductive age.* VAD impacts on mortality of women of reproductive age. An estimated 519 maternal deaths were attributed to VAD in pregnant women in South Africa in 2000 (Steyn *et al.,* 2006a:23).

2.3.1.3 Indicators

Biological indicators for VAD are listed below (Gibson, 2005; WHO, 1996).

- *Functional indicators*, such as night blindness/poor dark adaptation.
- *Biochemical indicators*, such as serum retinol, serum retinol binding protein, serum retinol ester, serum carotenoids, breast milk retinol, relative dose response (RDR), modified relative dose response (MRDR), serum 30-day dose response (+ S30DR) and stable isotope methods. Serum retinol concentration is the biochemical indicator used most often. For the individual, VAD can be categorised as marginal (serum retinol <20 µg/dL) or severe (serum retinol <10 µg/dL).
- *Histological indicators*, such as conjunctival impression cytology, and impression cytology with transfer.

A composite of non-specific but supportive ecological and demographic indicators can be useful to locate populations at risk for VAD. These indicators include nutritional status and dietary intake, illness and disease patterns, and socio-economic variables (WHO, 1996:3).

From a public health perspective the criteria given in tables 2.6 and 2.7 can be used to define VAD as a public health problem.

TABLE 2.6: CRITERIA FOR ASSESSING THE PUBLIC HEALTH SIGNIFICANCE OF CLINICAL VITAMIN A DEFICIENCY, BASED ON PREVALENCE AMONG 6-71-MO-OLD CHILDREN IN THE COMMUNITY

(Prevalence of any one or more indicators signifies a public health problem)[a]

Indicator	Prevalence
Bitot's spot	>0.5%
Corneal xerosis / ulceration / keratomalacia	>0.01%
Xerophthalmia-related corneal scar	>0.05%

[a] Night blindness is a symptom included in the classification of xerophthalmia together with the other clinical signs. A prevalence of night blindness >1.0% in 24-71-mo-old children indicates a public health problem. Serum retinol concentration is often used with the clinical classification as supportive evidence for vitamin A deficiency. A prevalence of >5% of serum retinol <10 µg/dL (<0.35µmol/L) is strong corroborative evidence of any clinical criteria met to identify an urgent health problem.
Source: WHO, 1996:6

TABLE 2.7: CRITERIA FOR ASSESSING THE PUBLIC HEALTH SIGNIFICANCE OF SUB-CLINICAL VITAMIN A DEFICIENCY, BASED ON PREVALENCE AMONG 6-71-MO-OLD CHILDREN IN THE COMMUNITY

Biological indicator	Prevalence cut-off values to determine a public health problem and its level of importance		
	Mild	**Moderate**	**Severe**
FUNCTIONAL			
Night blindness I present at 24-71 mo	>0 - <1%	≥1% - <5%	≥5%
BIOCHEMICAL			
Serum retinol ≤20 μg/dL[a]	≥2% - <10%	≥10% - <20%	≥20%
Breast milk retinol ≤30 μg/dL[b] or ≤8 μg/g milk fat	<10%	≥10% - <25%	≥25
Relative dose response ≥20%	<20%	≥20% - <30%	≥30%
Modified relative dose response ratio ≥0.06	<20%	≥20% - <30%	≥30%
Serum 30-day dose response ≥20%	<20%	≥20% - <30%	≥30%
HISTOLOGICAL			
CIC/ICT[c] abnormal at 24-71 mo of age	<20%	≥20% - <40%	≥40%

There is a public health problem of VAD when:
(i) the prevalence of at least two of the biological indicators of VAD is below the cut-off value
Or when
(ii) one biological indicator of deficiency is supported by at least four (two of which are nutrition and diet related) of a composite of demographic and ecological risk factors[d] such as:
- IMR>75/1000 live births; under 5 y MR >100/1000 live births;
- full immunization or, particularly measles immunization coverage, in <50% of 12-23-mo-old children;
- two-week period of prevalence of diarrhoea ≥20%
- no formal schooling for ≥50% of 15-44-y-old women
- <50% of households with a safe water source

Nutrition and diet-related risk factors
- <50% prevalence of breastfeeding in 6-mo-old infants
- <75% of vulnerable groups consume vitamin A-rich foods at least 3 times/week
- median dietary intake <50% of recommended safe level of intake among 75% of 1-6-y-old children
- ≥30% of children under 5 y are stunted
- ≥10% of children under 5 y are wasted
- ≥15% prevalence of low birth weight (<2 500g)

[a] ≤0.7μmol/L; [b] ≤1.05 μmol/L; [c] CIC = Conjunctival Impression Cytology; ICT = Impression Cytology with Transfer
[d] the cut-off values suggested for demographic and ecologic risk factors are arbitrary
Source: WHO, 1996:7-11

2.3.1.4 Prevalence of vitamin A deficiency in South Africa

The prevalence of VAD in 6-71-mo-old children as determined by the SAVACG study in 1994 is given in table 2.8. Differences between provinces occurred. Northern Cape (18.5%) and Western Cape (21.0%) had the lowest prevalence of VAD, while KwaZulu-Natal (38.9%) and Limpopo (43.5%) had the highest prevalence. Those living in rural areas and with poorly educated mothers were most affected.

TABLE 2.8: PREVALENCE OF VITAMIN A DEFICIENCY[a] IN 6-71-MO-OLD CHILDREN IN SOUTH AFRICA IN 1994

	N	%
South Africa	4 283	33.3
Rural	2 168	37.9
Urban	2 040	25.1
Northern Cape	497	18.5
Western Cape	403	21.0
Gauteng	321	23.5
Free State	626	26.8
Eastern Cape	734	31.1
North-West	442	32.0
Mpumalanga	460	33.0
KwaZulu-Natal	511	38.0
Limpopo	559	43.5

[a] serum retinol <20 µg/dL
Source: Labadarios *et al.*, 1995

The prevalence of VAD in children as reported in smaller studies is given in table 2.9. These studies showed that there are pockets within the provinces where the prevalence of VAD is substantially higher than that reported at provincial level. A study in rural KwaZulu-Natal showed that home-deliveries, the attitude of the caregiver towards family life, and the health status of the infant were risk factors for VAD. All infants who were underweight and all infants of widowed care-givers were vitamin A deficient (Faber & Benadé, 2000).

TABLE 2.9: PREVALENCE OF VITAMIN A DEFICIENCY[a] IN CHILDREN AS DETERMINED IN SMALLER STUDIES IN SOUTH AFRICA

	Age group	N	%	Source
KwaZulu-Natal	6-12 mo	289	18	Faber *et al.,* 2005
KwaZulu-Natal	4-24 mo	115	37.3	Faber & Benadé, 1999
KwaZulu-Natal	2-5 y	164	50.0	Faber *et al.,* 2001
KwaZulu-Natal	6-71 mo 6-11 y	105 131	45.9 51.6	Oelofse *et al.,* 1999
KwaZulu-Natal	6-11 y	228	40	Van Stuijvenberg *et al.*, 1999
Western Cape Cloetesville Kayamandi	 6-12 mo	 42 47	 2 23	Oelofse *et al.,* 2002
Western Cape Urban	 6-11 y	 228	 59	Sickle *et al.,* 1998
Western Cape Breastfeeding infants	 ≤ 6 mo	 104	 10	Sibeko *et al.*, 2004

[a] serum retinol <20µg/dL; R = rural; U = urban

The prevalence of VAD in adults as determined by smaller studies is given in table 2.10. It should be noted that different cut-off values (see indicator column) were used in the studies summarised in table 2.10. A high prevalence of VAD was observed in HIV+ patients (table 2.10). It was further shown that the number of patients with low levels of plasma retinol was significantly higher among those with stage III and IV disease, compared with patients with early disease (Visser *et al.,* 2003).

TABLE 2.10: PREVALENCE OF VITAMIN A DEFICIENCY IN ADULTS AS DETERMINED IN SMALLER STUDIES IN SOUTH AFRICA

		Sex	N	Indicator	%	Source
KwaZulu-Natal		F	127	serum retinol <30 µg/dL	24.4	Oelofse *et al.,* 1999
		F	137	serum retinol <30 µg/dL	30.0	Faber *et al.,* 2001
North-West	Rural	M	314	serum retinol <20 µg/dL	1	Kruger *et al.,* 2005
		F	440	serum retinol <20 µg/dL	1.8	
	Urban	M	447	serum retinol <20 µg/dL	1.9	
		F	570	serum retinol <20 µg/dL	1.6	
Western Cape HIV+ patients		M&F	137	plasma retinol <30 µg/dL	52	Visser *et al.,* 2003
Western Cape Breastfeeding mothers		F	113	serum retinol <30 µg/dL	4.5	Sibeko *et al.*, 2004

R = rural & U = urban; F = female & M = male

2.3.2 Iron deficiency

Iron is an essential micronutrient needed for transferring oxygen from the lungs to tissues, and for electron and enzyme transport (Gibson, 2005:443). Iron deficiency is the most common and widespread nutritional disorder in the world (WHO, 2001:15) and is particularly prevalent in infants, children and pregnant women (Gibson, 2005:444). Iron deficiency is most common among groups of low socioeconomic status (Gibson, 2005:21).

2.3.2.1 Causes

Iron balance in the body is maintained by three main factors, namely, (i) intake, (ii) storage and (iii) loss (Gibson, 2005:444).

(i) *Intake* depends on
- quality of iron in the diet (heme iron versus non-heme iron)
- bioavailability of the iron in the diet
- capacity to absorb iron, which depends on (a) the nutritional needs of the individual and (b) factors influencing the bioavailability, such as phytate, polyphenols and certain vegetable proteins (inhibit non-heme iron absorption); calcium (inhibits both heme and non-heme iron); and vitamin C, organic acids and animal tissue e.g. meat, fish and poultry (enhance non-heme iron absorption)

(ii) *Storage:* the amount of iron in the stores varies widely, depending on sex and iron status
(iii) *Loss*: small amounts are lost in the faeces; women have a bigger loss due to menstruation

Iron deficiency develops when the intakes of bioavailable iron do not meet requirements or when excessive physiological or pathological losses of iron occur. The prevalence of iron deficiency varies greatly according to age, gender, and physiological, pathological and socioeconomic conditions (WHO, 2001:17). The most common risk factors contributing to iron deficiency are given in table 2.11.

TABLE 2.11: RISK FACTORS FOR DEVELOPING IRON DEFICIENCY

Risk factor	Mechanism
Low consumption of meat	Low intake of (bioavailable) dietary heme iron
High consumption of phytates	Reduced absorption (bioavailability) of dietary non-heme iron
Rapid growth	Increased (physiological) requirements
Menstruation	Increased (physiological) losses
Pregnancy	Increased (physiological) requirements
Prematurity and low birth weight	Low body stores
Sensitivity to cow's milk	Occult (stool) blood losses
Parasitic infections in gastrointestinal tract	Increased losses through blood loss
Malaria	Increased loss through haemolysis

Sources: Yip, 2001: 329; WHO, 2001.

2.3.2.2 Consequences

Functional consequences of a poor iron status are listed below (WHO, 2001:7-10; Gibson, 2005:444-445).

- impaired psychomotor development and cognitive performance in children
- behavioural disturbances such as pica, characterised by the abnormal consumption of non-food items
- reduced work capacity, productivity, physical activity, aerobic capacity and endurance capacity
- impaired immune status and lowered resistance to infection
- impaired growth of infants and children
- for pregnant women, increased maternal mortality, prenatal and perinatal infant loss and prematurity
- increased overall infant mortality

- impaired temperature response to a cold environment
- increased risk of heavy-metal (e.g. lead) poisoning in children

In the report by Steyn *et al.* (2006a:23) it is mentioned that it is estimated that more than 3 000 perinatal deaths were attributed to iron deficiency anaemia in South Africa in 2000.

2.3.2.3 Indicators

Three stages can be distinguished in the development of iron deficiency anaemia (Gibson, 2005:445).

1st stage: In *iron depletion* the amount of storage iron is progressively reduced.

2nd stage: *Iron-deficient erythropoiesis* is characterised by the exhaustion of iron stores and is sometimes called “iron deficiency without anaemia”.

3rd stage: In *iron deficiency anaemia* the circulating iron levels decline and microcytic (small cells), hypochromic (pale cells) anaemia is present.

There are several tests to determine iron status. Iron deficiency anaemia is defined as meeting the criteria of both iron deficiency and anaemia based on haemoglobin (Hb) and haematocrit values. Low Hb or low haematocrit is therefore the most commonly used indicator. The cut-off values for Hb and haematocrit concentrations below which anaemia is present are given in table 2.12. However, Hb is not a sensitive indicator of iron status as the levels only drop once the third stage of iron deficiency is reached. Also, a major limitation of Hb and haematocrit values is the fact that anaemia is not a specific indication of iron deficiency. Normal Hb distributions vary with age, gender, and race, and at different stages of pregnancy, as well as with variations in altitude and with cigarette smoking. Certain other micronutrient deficiencies, parasitic infections and certain disease states also affect Hb concentrations (Gibson, 2005:446-447; WHO, 2001:33).

TABLE 2.12: HAEMOGLOBIN AND HAEMATOCRIT CONCENTRATION BELOW WHICH ANAEMIA IS PRESENT IN INDIVIDUALS LIVING AT SEA LEVEL

Age or gender group	Haemoglobin	Haematocrit	
	g/L	mmol/L	L/L
Children 6-59 mo	110	6.83	0.33
Children 5-11 y	115	7.13	0.34
Children 12-14 y	120	7.45	0.36
Non-pregnant women ≥15 y	120	7.45	0.36
Pregnant women	110	6.83	0.33
Men ≥15 y	130	8.07	0.39

Source: WHO, 2001:33

Other tests to determine iron status are listed below. Each of these reflects different aspects of iron metabolism and therefore has a different utility, sometimes indicating a specific stage in the development of iron deficiency. Consequently test results often differ, and therefore combinations of tests are used to derive a differential diagnosis.

- *Serum ferritin* reflects iron stores (concentrations <12 µg/dL for children <5 y, and <15 µg/dL for children >5 y and adults reflect depleted iron stores). Serum ferritin is an acute phase reactant and is therefore elevated in response to any infectious or inflammatory process; the use of serum ferritin is therefore problematic in the presence of infections (WHO, 2001:37-38).

- *Serum iron (SI), total iron binding capacity (TIBC), transferrin saturation*: iron deficiency results in a reduction in SI concentrations, an elevation in TIBC, and hence a net reduction in transferrin saturation (i.e. SI/TIBC) (WHO, 2001:40).
- *Erythrocyte protoporphyrin* concentrations are elevated when iron supply is inadequate for haem production; it can be used to screen for moderate iron deficiency without anaemia in settings where infections, lead poisoning and other forms of anaemia are rare (WHO, 2001:38-39).
- *Serum transferrin receptor* levels increase progressively as the supply of iron to tissues becomes progressively deficient. The assay is not affected by infection or inflammation, and it does not vary with age, gender, or pregnancy (WHO, 2001:40).
- Red cell indices include *mean cell volume* (MCV), *mean cell haemoglobin* (MCH) and *mean cell haemoglobin concentration* (MCHC) (Gibson, 2005:452-453).
- *Red cell distribution width* increases in iron deficiency anaemia (Gibson, 2005:454)

2.3.2.4 Prevalence of iron deficiency in South Africa

The prevalence of iron deficiency in 6-71-mo-old children as determined by the SAVACG study in 1994 is given in table 2.13. Differences between provinces occurred. KwaZulu-Natal (10.4%) had the lowest prevalence of anaemia, while Western Cape (28.6%) and Limpopo (34.2%) had the highest prevalence. The prevalence of iron deficiency for children as reported in smaller studies is given in table 2.14 and for adults in table 2.15. These studies showed that there are pockets within provinces where the prevalence of iron deficiency is substantially higher than that reported at provincial level.

TABLE 2.13: PREVALENCE OF IRON DEFICIENCY IN 6-71-MO-OLD CHILDREN IN SOUTH AFRICA IN 1994 AS DETERMINED BY THE NATIONAL SAVACG STUDY; PER PROVINCE

	N[a]	Anaemic[b]	Iron depleted[c]	Iron deficiency anaemia[d]
South Africa	4 206 – 4 494	21.4	9.8	5.0
Rural	2 107 – 2264	21.1	8.3	4.6
Urban	2 032 – 2 169	20.7	12.1	5.4
KwaZulu-Natal	474 – 516	10.4	13.4	3.5
Gauteng	332 – 390	16.3	9.2	3.8
Free State	601 – 646	17.1	6.8	3.9
Eastern Cape	457 – 498	20.6	5.0	2.4
Northern Cape	475 – 513	21.5	10.9	6.5
North-West	462 – 553	24.5	8.1	5.0
Mpumalanga	461 – 500	27.7	11.5	7.0
Western Cape	392 – 413	28.6	16.4	8.2
Limpopo	552 – 578	34.2	11.0	9.1

[a] Sample size varies for the different indicators
[b] Hb < 110 g/L; [c] Ferritin < 12 µg/dL; [d] Hb < 110 g/L and Ferritin < 12 µg/dL
Source: Labadarios *et al.*, 1995

TABLE 2.14: PREVALENCE OF IRON DEFICIENCY IN CHILDREN AS DETERMINED IN SMALLER STUDIES IN SOUTH AFRICA

	Age	N	Indicator	%	Source
KwaZulu-Natal	4-24 mo	115	Hb <110 g/L	43.2	Faber & Benadé, 1999
			Serum feritin <10 µg/dL	65.2	
KwaZulu-Natal	6-12 mo	289	Hb <110 g/L	44	Faber *et al.*, 2005
			Serum feritin <10 µg/dL	59	
KwaZulu-Natal	6-71 mo	105	Hb <110 g/L	23.8	Oelofse *et al.*, 1999
			Serum feritin <10 µg/dL	19.8	
	6-11 yrs	131	Serum feritin <10 µg/dL	7.1	
			Hb <120 g/L	22.0	
KwaZulu-Natal	2-5 yrs	154	Hb <110 g/d	54	Faber *et al.*, 2001
			Serum feritin <10 µg/dL	33	
KwaZulu-Natal	6-11 yrs	225	Hb <120 g/L	27	Van Stuijvenberg *et al.*, 1999
Western Cape	6-12 mo	42	Hb <110 g/L	64	Oelofse *et al.*, 2002
Cloetesville			Serum feritin <10 µg/dL	34	
			Iron deficiency anemia[1]	32	
Kayamandi		47	Hb <110 g/L	83	
			Serum feritin <10 µg/dL	39	
			Iron deficiency anemia[1]	46	
Western Cape	6-11 yrs	228	Hb < 119 g/L	12.3	Sickle *et al.*, 1998
			Serum feritin <10 µg/dL	3.5	
Western Cape	≤ 6 mo	104	MCV <73 fl	2.8	Sibeko *et al.*, 2004
Breastfeeding			Hb <110 g/L	50	
infants			Haematocrit <37%	37	

[1] Hb <110 g/L and serum feritin <10 µg/dL or transferrin saturation <8%

TABLE 2.15: PREVALENCE OF IRON DEFICIENCY IN ADULT FEMALES AS DETERMINED IN SMALLER STUDIES IN SOUTH AFRICA

	Sex	N	Indicator	%	Source
KwaZulu-Natal	F	127	Serum feritin <12 µg/dL	18.9	Oelofse *et al.*, 1999
			Hb <120 g/L	21.8	
KwaZulu-Natal	F	137	Serum feritin <12 µg/dL	19	Faber *et al.*, 2001
			Hb <120 g/L	44	
North-West Rural	M	314	Serum feritin <12 µg/dL	2.5	Kruger *et al.*, 2005
			TIBC >360 µg/100 mL	0	
			Hb <130 g/L	7.5	
			Haematocrit <40%	0	
	F	440	Serum feritin <12 µg/dL	14.7	
			TIBC >360 µg/100 mL	0	
			Hb <120 g/L	10.1	
			Haematocrit <40%	0	
Urban	M	447	Serum feritin <12 µg/dL	3.3	
			TIBC >360 µg/100 mL	0	
			Hb <130 g/L	6.9	
			Haematocrit <40%	0	
	F	570	Serum feritin <12 µg/dL	16.8	
			TIBC >360 µg/100 mL	0	
			Hb <120 g/L	15.7	
			Haematocrit <40%	0	
Western Cape	F	113	MCV <80 fl	13	Sibeko *et al.*, 2004
Breastfeeding mothers			Hb <120 g/L	32	
			Haematocrit <36%	20	

2.3.3 Iodine deficiency

Iodine is an essential micronutrient for thyroid hormone metabolism, and is required for optimal growth and development (Gibson, 2005:749). Women of reproductive age, pregnant women and young children are at highest risk of iodine deficiency. At school-going age girls tend to be at higher risk than boys (Gibson, 2005:752).

2.3.3.1 Causes

Inadequate dietary iodine intake is the most common cause of iodine deficiency (Gibson, 2005:752). Iodine deficiency is generally caused by lack of iodine in drinking water and in the soil and water used for crops (West *et al.*, 2004:224).

Secondary dietary factors that may contribute to iodine deficiency include goitrogens, which are substances that can block the absorption or utilisation of iodine and thus reduce its intake into the thyroid gland. Goitrogens are abundant in some vegetables, especially those of the Brassicaceae family, particularly cabbage and turnips. Goitrogens are also present in cassava and soybeans (Gibson, 2005:752).

2.3.3.2 Consequences

Iodine deficiency results in goitre, cretinism, abnormal growth and development, reproductive failure and perinatal and infant mortality (Gibson, 2005:751). The most critical period for iodine deficiency is during foetal life and early childhood. The effects of hypothyroxinemia in the development of the brain and central nervous system between the 15th week of gestation and the 3rd year of life are irreversible and may lead to permanent neurological defects and deficient learning abilities (West *et al.*, 2004:222).

2.3.3.3 Indicators

Clinical and biochemical methods for assessing iodine status are listed below (Gibson, 2005:754-765; Semba, 2001:353-354).

- *Thyroid size* by neck palpation: By this method a classification consisting of three grades is used, namely, grade 0 (no palpable or visible goitre), grade 1 (palpable but not visible), and grade 2 (visible goitre).
- *Thyroid volume* by ultrasonography is more precise and objective than neck palpation, especially if the visible goitre is small.
- *Urinary iodine excretion* either in 24-hr urine samples or casual urine specimens is the most widely used biochemical method to assess iodine status. Urinary iodine values are not usually normally distributed, so the median value should always be reported. Epidemiological criteria for assessing severity of IDD based on median urinary iodine levels are given below.

Median value	Severity of IDD
<20 μg/L	Severe IDD
20-49 μg/L	Moderate IDD
50-99 μg/L	Mild IDD
100-199 μg/L	Optimal
200-299 μg/L	Risk of iodine-induced hyperthyroidism
>300 μg/L	Risk of adverse health consequences

- *Thyroid stimulating hormone* in serum or whole blood is used as a screening tool for congenital hypothyrodism in neonates – whether it can be used to assess iodine status is less clear.
- *Serum thyroglobulin* reflects iodine intake over a period of months.

- *Levels of thyroxine* and *triiodothyronine* in serum, although they are relatively insensitive, generally only falling below the normal range when iodine deficiency is very severe.
- *Uptake of* radioactive ^{131}I is used as a test of thyroid function in clinical settings.

2.3.3.4 Prevalence of iodine deficiency in South Africa

Before 1995, dietary iodine deficiency was widespread in South Africa (Benadé *et al.*, 1997; Kalk *et al.,* 1998). The recommended method for preventing iodine deficiency globally is through the use of iodized salt (Gibson, 2005:753). In South Africa mandatory iodization of household salt was introduced through revised legislation in December 1995. A series of studies showed that iodization of salt resulted in dramatic improvements in the short term, both for process and outcome indicators of iodine deficiency and endemic goitre (Witten *et al.*, 2001). However, people of the three northern provinces of the country, rural people, households using predominantly poorly iodized coarse salt, and low socio-economic households are still exposed to under- or non-iodized salt (Witten *et al.*, 2001). A study in the North-West Province showed that urban people had a higher median urinary iodine concentration than rural people. Many rural people used non-iodated salt (Kruger *et al.,* 2005).

2.3.4 Zinc deficiency

Zinc is an essential micronutrient needed for physical growth, immunocompetence, reproductive function, and neuro-behavioural development (Hotz & Brown, 2003:S101). Epidemiological data on zinc deficiency remains scarce, predominantly due to a lack of reliable indicators for zinc status, but zinc deficiency is considered as important as iron deficiency (ACC/SCN, 2000).

2.3.4.1 Causes

The most common cause of zinc deficiency is an inadequate dietary intake of absorbable zinc. Other causes include increased requirement, malabsorption, increased losses and impaired utilisation. The phytate:zinc molar ratio in food affects zinc absorption, and the requirements for zinc increase if the diet contains largely unprocessed cereals and roots and negligible amounts of animal source foods (Hotz & Brown, 2003:S99-123). Two genetic disorders (Acrodermatitis enteropathica and sickle cell disease) can cause zinc deficiency. Secondary zinc deficiency has been reported in the presence of malabsorption syndromes and other diseases (e.g. liver and renal disease, AIDS, alcoholism) (Gibson, 2005:713). Underlying social and economic risk factors include poverty, poor quality food supply, poor personal hygiene and poor environmental sanitation (Hotz & Brown, 2003:S123). Vulnerable groups at risk for zinc deficiency include infants and young children, adolescents, pregnant and lactating women, the elderly, low birth-weight infants, and malnourished infants and children (Hotz & Brown, 2003:S99-129).

2.3.4.2 Consequences

The physiological consequences of zinc deficiency are non-specific, vary widely and depend to a large extent on the severity of the deficiency, and the affected individual's sex and age. The signs of zinc deficiency are listed below (Hotz & Brown, 2003: S99-129; Shrimpton, 2001:315).

- impaired immunocompetence and increased prevalence and incidence of childhood infections, such as diarrhoea and pneumonia, which may result in increased rates of mortality
- increased infection rate and recurrent infections
- diarrhoea

- cognitive function impairment, behavioural problems, mood changes, memory impairment, problems with spatial learning, and neuronal atrophy
- impaired growth and development of infants, children and adolescents
- more skin lesions as the child grows older
- hair loss (alopecia), inflammation of the eyelids and conjunctiva and recurrent infections among school-aged children
- impaired maternal health and pregnancy outcomes
- delayed wound healing; chronic non-healing leg ulcers among the elderly
- anorexia (loss of appetite), which may result in a decreased food intake and other nutrient deficiencies
- hypogeusia (decreased sense of taste)

2.3.4.3 Indicators

Assessment of zinc status is challenging because as yet there is no single, sensitive and specific as well as practical and low-cost indicator of zinc status. Biochemical and functional tests that have been used in the evaluation of zinc status are listed below (Gibson, 2005:715-731; Hotz & Brown, 2003:S143-162).

- Serum and plasma zinc concentrations are the most widely accepted biochemical indicators of zinc status, and is useful for assessing zinc status at the population level. Testing of these at the individual level is however limited because there are many factors that affect serum zinc concentrations. These include acute infections and inflammation, diurnal variation, oral contraceptive use and other hormone treatment, hemodilution during pregnancy, haemolysis, malabsorption syndromes, and chronic diseases such as cirrhosis and PEM. In addition, age, sex, fasting status and time of day of sample collection must be taken into consideration when interpreting serum zinc concentrations. Prolonged use of a tourniquet during blood drawing, contamination during blood collection, and storage of blood samples prior to separation of the serum may affect the serum zinc concentration.
- Hair zinc concentrations are more stable than serum zinc concentrations, but testing of these is limited because of a lack of established cut-off values and uncertainties in interpreting results in malnourished children.
- Other biochemical indicators include zinc-dependent enzymes; leukocyte, erythrocyte and platelet zinc; metallothionein; serum thymulin; monocyte metallothionein messenger RNA; kinetic markers for pool size and turnover rate; urine zinc concentration (only sensitive to extremes of zinc intake); and salivary zinc. However, these indicators are currently not recommended for testing of populations.
- An oral zinc tolerance test measures the increase in plasma zinc from fasting level after oral ingestion of a pharmacological dose of zinc.
- Taste-acuity tests can also be undertaken.

Indirect measurements have been suggested for establishing the likelihood that zinc deficiency is an important public health problem in populations.

- Zinc deficiency affects linear growth of infants and young children. A prevalence of stunting ≥20% may indicate an increased likelihood of zinc deficiency, in which case further assessment of zinc status should be considered (Hotz & Brown, 2003:S132).
- The nutritional causes of iron deficiency and zinc deficiency are similar (iron and zinc have a similar distribution in the food supply), and high rates of IDA may therefore be suggestive of zinc

deficiency. It must be recognised though that anaemia does not necessarily indicate the presence of zinc deficiency (Hotz & Brown, 2003:S134-135).

A prevalence of 10-20% for low serum zinc suggests that some segments of the population may be at high risk of zinc deficiency. If the prevalence of low serum zinc exceeds 20%, national programmes may be considered (Hotz & Brown, 2003:S152).

2.3.4.4 Prevalence of zinc deficiency in South Africa

Hardly any data on zinc deficiency are available for South Africa. Two studies reported the prevalence of zinc deficiency in infants (table 2.16). In addition a study on HIV+ patients showed that the number of patients with low plasma zinc concentrations was significantly higher among those with stage III and IV disease (36-45%) compared with patients with early disease (20%) (Visser *et al.,* 2003).

TABLE 2.16: PREVALENCE OF ZINC DEFICIENCY IN CHILDREN AS DETERMINED IN SMALLER STUDIES IN SOUTH AFRICA

	Age group	N	Indicator	%	Source
KwaZulu-Natal	6-12 mo	289	Serum zinc <9.9 μmol/L	45	Faber *et al.,* 2005
Western Cape					
Cloetesville	6-12 mo	42	Serum zinc < 65 μg/dL	35	Oelofse *et al.,* 2002
Kayamandi		47		32	

2.3.5 Multiple micronutrient deficiencies

Although the major micronutrient deficiencies are reviewed individually, multiple micronutrient deficiencies often occur. A conceptual framework that describes the mechanisms by which multiple micronutrient malnutrition may occur, including some of the consequences in maternal and child health, and nutrition and the link to food and energy intake, is given in figure 2.1 (Ramakrishnan & Huffman, 2001:365-391). From the figure it is clear that micronutrient deficiencies tend to interact and cluster. Thus a “multi-nutrient” integrated approach would be indicated if the final outcome (improved child growth) is to be achieved. Furthermore, it is evident that a whole diet approach is advisable, in contrast to a single food focus. Finally, a long-term commitment ensuring healthy pregnancy would be the ideal situation to improve child growth and development. Because nutrient deficiencies are interrelated, a broad, multifaceted, comprehensive health intervention programme is needed to address childhood malnutrition (Coutsoudis *et al.,* 1994).

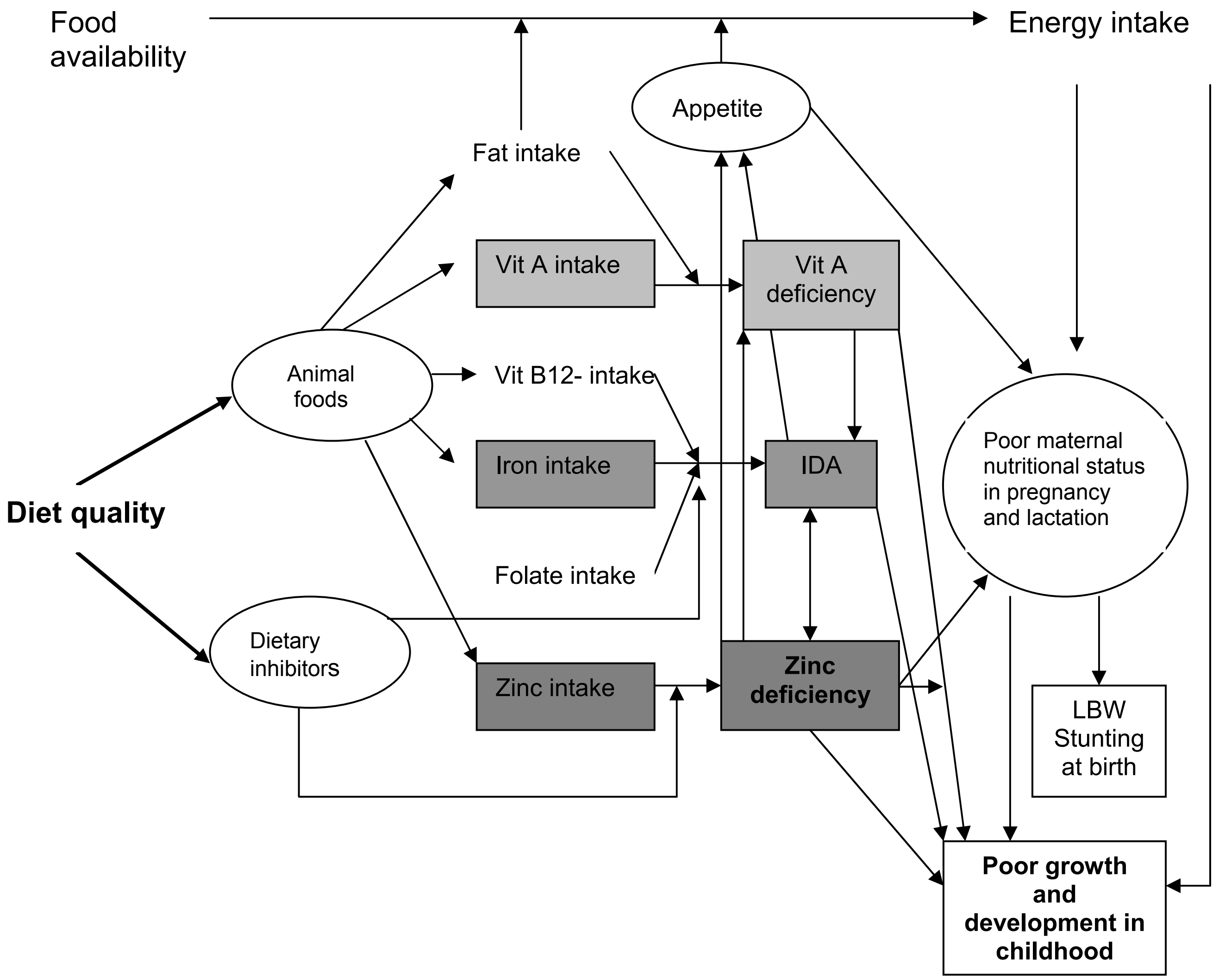


FIGURE 2.1: MULTIPLE NUTRITIONAL DEFICIENCIES: A COMPLEX WEB
Source: based on Ramakrishnan & Huffman, 2001:366

2.4 NUTRIENT INTAKE AND FOOD CONSUMPTION IN CHILDREN

From the previous section (figure 2.1) the importance of dietary intake, in terms of food, energy, nutrients and the diet as a whole, has become evident. A report by Steyn *et al.* (2006a:5) stated that westernised eating patterns are reflected by the high prevalence of overweight and obesity in the South African adult and child population, despite the fact that stunting and chronic energy deficiency affects a large number of infants and children. This section will focus on the dietary intake of children.

2.4.1 Nutrient intake

The NFCS of 1999 showed that a large number of children had an inadequate intake of vitamin A, vitamin C, thiamine, riboflavin, niacin, vitamin B_6, vitamin B_{12}, folic acid, calcium, iron and zinc (see table 2.17). Rural children were worse off than urban children, in line with trends from 36 developing countries (Smith *et al.*, 2004). Food insecurity, whether due to food accessibility or availability, was directly related to an inadequate dietary intake and increased levels of stunting and underweight.

Inadequate intake of micronutrients starts during infancy. Oelofse *et al.* (2002) showed in two urban areas that particularly iron and zinc intakes were low during infancy. Faber (2005) reported that complementary foods consumed by rural infants were of low nutrient density, especially for iron, zinc and calcium.

2.4.2 Food consumption

Food consumption is one of the most important factors in the aetiology of malnutrition. Food items consumed most frequently by 1-9-y-old children as reported during the NFCS are listed in table 2.18. The foods are ranked according to the total number of times that the food was reported for all the children during the recall period. The percentage of children consuming these foods and the average amount of the food item eaten per day for consumers are also given. Maize was one of the most frequently and consistently consumed food items, followed by whole milk and brown bread. Differences between provinces were observed.

Cereals were consumed by 99% of all children. The average consumption of cereals was 493 g for 1-5-y-old children, 559 for 6-9-y-olds and 690-879 g for 10+ y olds when taking the groups of consumers into consideration (Nel & Steyn, 2002). Dietary diversity for South African children was shown to be low (Steyn *et al.,* 2006c). Overall, the contribution to all nutrients by fruit and vegetables was very low, as were the per capita portions. Consumption of fruit and vegetables was low because of low access and low availability (Steyn *et al.,* 2006b).

Fruit and vegetable intake needs to be increased in South African children (Steyn *et al.,* 2006b). This can be achieved through, for example, home gardens. In a study in rural KwaZulu-Natal, promotion of local production of β-carotene crops lead to an increase in vitamin A and micro-nutrient intake and ultimately vitamin A status in 2-5-y-old children (Faber *et al.,* 2002a, 2002b).

In the North-West province it was shown that urban adults ate a variety of food, whereas rural adults, especially those living on large commercial farms, ate mainly staple foods. The varied diets of the urban adults contributed to higher intakes of most vitamins and iron and to higher serum retinol concentrations. Adults from urban areas had significantly higher dietary intakes of most micronutrients than rural adults. Urban adults had higher intakes of animal protein, fruit and vegetables than rural adults (Kruger *et al.,* 2005).

TABLE 2.17: PERCENTAGE OF 1-9-Y-OLD CHILDREN WHO CONSUMED LESS THAN 67% OF THE RDA AS REPORTED IN THE NFCS

Nutrient	Age group	Eastern Cape	Free State	Gauteng	KwaZulu-Natal	Mpumalanga	Northern Cape	Limpopo	North-West	Western Cape	RSA	Urban	Rural
N	1-3 y	168	96	241	237	60	82	147	115	162	1308	664	644
	4-6 y	170	83	136	217	65	55	144	81	132	1083	513	570
	7-9 y	86	29	50	101	37	16	61	34	63	477	239	238
Energy	1-3 y	37.5	61.5	49	32	63	72	58.5	45	23	45	41	49
	4-6 y	47	66	54	33	58.5	62	56	57	25	47	41	53
	7-9 y	48	72	64	37	59.5	56	64	65	29	50.5	45	56
Protein	1-3 y	12	13.5	7	4.5	10	20.5	11.5	5	2	8.5	8.5	8
	4-6 y	12.4	13.5	7.5	4	9	18	15.5	18.5	4.5	10	6.5	13.5
	7-9 y	20	17	16	7	8	31.5	13	6	0	11.5	7.5	15.5
Vitamin A	1-3 y	68	76	71	62	85	74	56	79	36	65	60	70
	4-6 y	75	78	65	76	82	80	49	81	50	69	64	73
	7-9 y	83	83	84	86	84	87	66	94	56	79	72	85
Vitamin C	1-3 y	74	80	70	65	82	77	83	80	38	69	62	78
	4-6 y	76	88	74	67	75	78	80	70	49	72	67	76
	7-9 y	78	72	72	67	70	100	80	74	44	70	64	77
Thiamin	1-3 y	20	32	23	12	20	50	23	22	14	22	22	21
	4-6 y	19	33	22	11	25	40	19	19	18	20	19	21
	7-9 y	21	24	28	8	14	44	11	9	17	17	16	17
Riboflavin	1-3 y	45	42	34	35	42	55	60	41	15	39	31	48
	4-6 y	66	67	55	55	68	64	71	64	27	58	46	69
	7-9 y	63	72	58	53	59	56	67	62	27	56	43	70
Niacin	1-3 y	64	72	46	39	53	54	50	44	20	47	39	54
	4-6 y	63	60	34	37	43	53	44	51	17	53	33	53
	7-9 y	57	45	42	34	35	50	33	41	14	38	30	46
Vitamin B_6	1-3 y	48	69	47	24	47	67	58	61	11	44	37	51
	4-6 y	45	64	37	22	41	60	53	59	15	40	31	48
	7-9 y	44	59	38	17	35	62	44	50	6	34	27	41
Vitamin B_{12}	1-3 y	53	47	44	41	40	56	73	43	16	45	37	53
	4-6 y	60	52	40	44	48	42	74	52	22	48	35	60
	7-9 y	58	55	50	50	54	37	66	44	14	49	33	64

Table 2.17 continues on the next page

TABLE 2.17: PERCENTAGE OF 1-9-Y-OLD CHILDREN WHO CONSUMED LESS THAN 67% OF THE RDA AS REPORTED IN THE NFCS *(CONTINUED)*.

Nutrient	Age group	Eastern Cape	Free State	Gauteng	KwaZulu-Natal	Mpuma-langa	Northern Cape	Limpopo	North-West	Western Cape	RSA	Urban	Rural
Folate	1-3 y	63	85	69	57	83	84	75	80	47	68	62	74
	4-6 y	52	89	64	45	72	64	72	81	32	59	52	65
	7-9 y	45	72	56	46	59	75	69	68	27	53	46	60
Iron	1-3 y	86	92	85	77	78	93	62	81	64	79	78	80
	4-6 y	74	88	63	59	71	82	42	68	45	63	59	66
	7-9 y	70	72	64	53	62	75	36	73	44	58	53	63
Zinc	1-3 y	89	94	89	85	90	91	84	90	70	86	82	90
	4-6 y	85	83	78	66	82	75	76	76	58	74	66	81
	7-9 y	80	83	74	66	78	88	70	79	52	72	63	81
Magnesium	1-3 y	8	5	5	3	7	15	8	3	2	5	5	6
	4-6 y	9	18	7	2	11	29	6	9	10	9	9	9
	7-9 y	14	17	8	4	0	31	2	6	3	7	6	9
Phosphorous	1-3 y	30	28	22	16	25	43	31	18	9	23	21	24
	4-6 y	23	22	15	9	18	33	19	20	10	17	13	21
	7-9 y	28	17	14	8	11	37	11	12	2	14	9	19

Source: Labadarios *et al.*, 2000

TABLE 2.18: MOST FREQUENTLY CONSUMED FOOD ITEMS FOR 1-9-Y-OLD CHILDREN AS REPORTED FOR THE 24-HR RECALL PERIOD DURING THE NFCS 1999

	National N=2868			Eastern Cape N=424			Free State N=208			Gauteng N=427			KwaZulu-Natal N=555			Limpopo N=352			Mpumalanga N=162			Northern Cape N=153			North-West N=230			Western Cape N=357		
	No	%	g/day	No	%	g/day	No	%	g/day	No	%	g/day	No	%	g/day	No	%	g/day	No	%	g/day	No	%	g/day	No	%	g/day	No	%	g/day
Maize	1	78	442	2	79	439	1	95	541	2	80	369	1	80	420	1	95	524	1	81	463	2	78	400	1	91	483	10	31	278
White sugar	2	76	21	1	80	31	3	58	16	1	80	18	2	76	20	2	59	16	2	80	17	1	80	24	2	85	22	1	86	23
Tea	3	46	235	3	46	277	4	46	220	4	47	230	3	56	226	5	42	227	4	60	227	4	43	215	4	60	225	16	24	252
Whole milk	4	42	167	5	36	159	2	66	203	3	54	130	9	26	122	9	13	144	6	27	186	5	41	125	3	64	141	2	64	247
Brown bread	5	37	101	11	20	90	5	34	98	5	45	86	5	37	104	3	58	117	3	60	116	8	19	95	5	34	107	13	28	90
White rice	6	27	140	4	37	185	14	9	102	11	18	117	4	37	173	21	6	171	15	14	172	6	22	109	13	13	152	3	57	82
White bread	7	27	96	6	36	102				8	26	91	7	30	108				17	10	93	3	46	75	14	12	99	5	57	89
Hard margarine	8	26	13	7	24	13	10	11	14	6	32	12	6	32	13	12	11	10	12	18	10	12	14	10	15	11	9	4	57	17
Chicken	9	25	80	14	12	68	7	16	81	7	30	70	11	25	104	6	29	71	5	36	76	11	17	80	7	25	66	9	36	85
Potatoes	10	22	117	9	22	129	8	15	112	12	17	94	10	26	149	23	6	134	9	21	98	9	18	98	9	20	122	6	48	99
Beef	11	17	108				11	10	86	9	25	88	14	18	143	10	13	131	8	22	81	14	14	87	10	15	97	12	29	108
Fruit (other)	12	15	159	21	8	132	12	9	162	10	19	149	19	10	146	11	12	151	14	15	165	17	12	218	19	9	154	8	41	169
Cabbage group	13	14	82	12	15	87	6	18	84	16	15	72	16	14	103	24	6	67	11	20	86	19	10	73	6	27	75			
Cordial with water	14	14	295	13	12	335	23	4	228	20	10	261	17	14	303	16	9	244	23	7	263							7	43	307
Eggs	15	13	74	18	9	72	15	8	100	15	17	79	18	12	62	14	9	77	13	18	79	15	13	71	16	11	80	18	21	70
Green leaves	16	12	142				9	12	124	19	12	110	20	10	144	4	46	155	18	10	155				25	5	89			
Rooibos tea	17	12	241	24	6	268	18	7	201	14	17	245				8	16	218	10	20	222				11	14	256	19	20	250
Sour milk	18	11	310	8	22	369				23	9	172	8	28	334															
Vegetables (other)	19	11	81				16	8	94	13	17	84	15	14	71	15	9	105	16	13	94	20	9	76	12	13	62			
Non-dairy milk	20	10	7										13	21	7	7	17	7	7	26	6				23	6	8			
Salty snacks	21	9	30	23	6	21				22	10	31	25	6	31	18	8	29	20	8	25							14	27	32
Pumpkin	22	9	92	17	10	106	19	7	103				22	7	107	25	5	80				16	12	115				20	20	82
Peanut butter	23	8	14	22	7	16				17	13	11				13	9	15										24	18	16
Breakfast cereals	24	8	40							18	12	41							25	7	58							11	31	38
Legumes	25	8	166				22	5	127				12	24	199							22	6	63						
Samp & beans				10	21	350																								
Soup				15	12	181	24	4	105							20	6	145												
Samp & rice				16	11	327																								

Table 2.18 continues on the next page

	National N=2868			Eastern Cape N=424			Free State N=208			Gauteng N=427			KwaZulu-Natal N=555			Limpopo N=352			Mpumalanga N=162			Northern Cape N=153			North-West N=230			Western Cape N=357		
	No	%	g/day	No	%	g/day	No	%	g/day	No	%	g/day	No	%	g/day	No	%	g/day	No	%	g/day	No	%	g/day	No	%	g/day	No	%	g/day
Magou				19	8	503																								
Coffee				20	8	219													24	7	237	10	17	299	18	9	265	23	19	214
Sweets				25	5	24																						15	24	28
Fruit (vit A)							13	9	195																					
Mutton							17	7	120													7	20	136	21	6	91			
Mabella							20	5	313																8	23	343			
Pilchards/sardines							21	5	143				21	7	79							21	6	91	17	10	87			
Sugar (brown)							25	3	15							17	8	14												
Sweet spreads										21	10	17										13	14	23				22	19	24
Pork & ham										24	8	37	24	6	27													21	19	47
Fruit juice										25	8	280	23	7	302	19	8	244				23	6	284	20	8	254	17	22	224
Gravy																			19	10	50									
Fat (PUS/med)																			21	8	7									
Salads																			22	8	73									
Animal fat																						18	11	14						
Vetkoek																						24	6	133	22	6	161			
Maize / samp rice																						25	6	188	18	9	265	23	19	214
Worms																22	6	63										15	24	28
Cookies / biscuits																									24	5	85			
Cheese																												25	15	24

Source: Labadarios *et al.*, 2000

2.5 CONCLUDING REMARKS

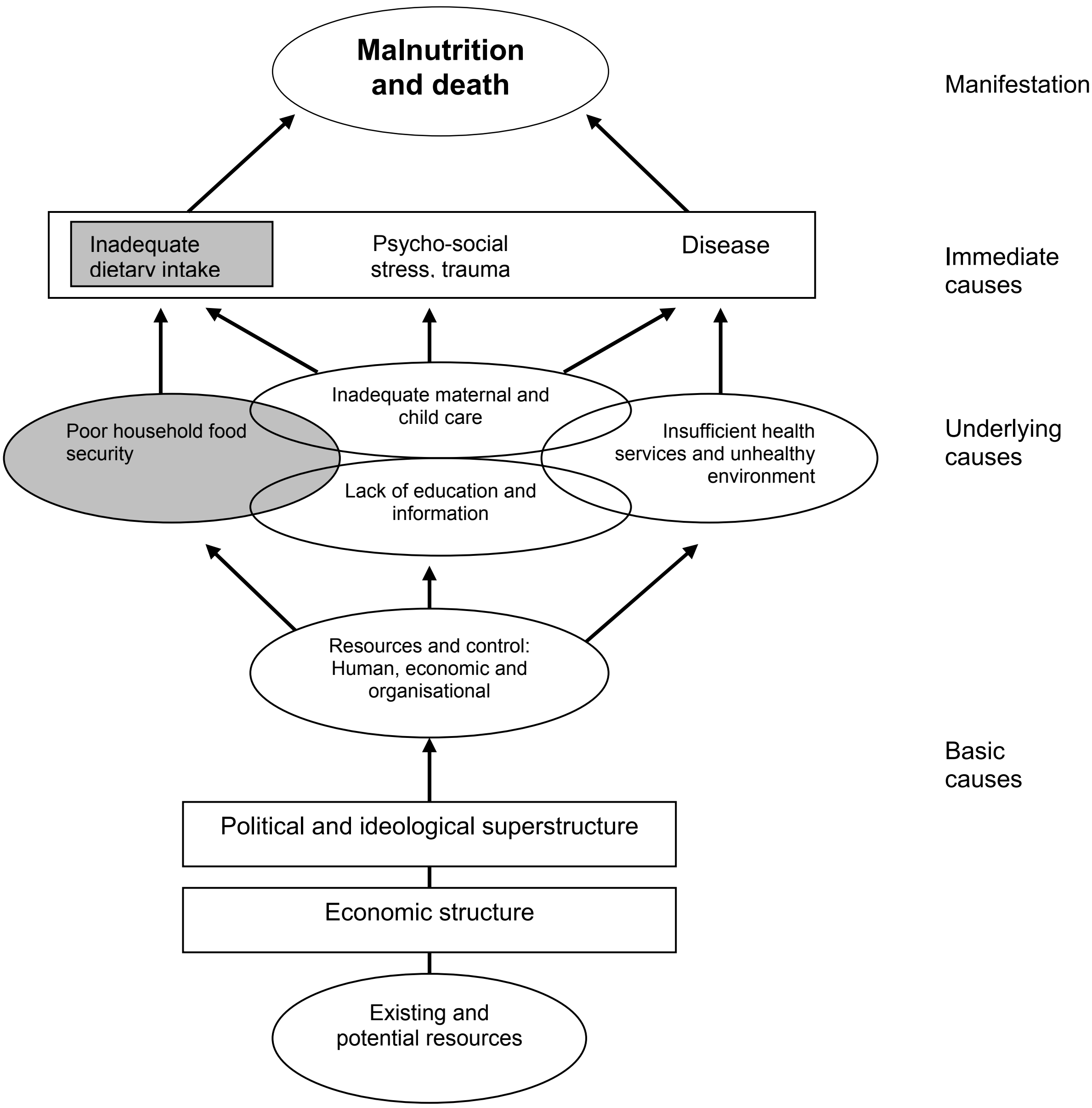
South Africa has a problem of chronic malnutrition rather than acute malnutrition. Childhood malnutrition starts early in life and often coincides with the introduction of complementary feeding (weaning period). In respect of stunting and underweight, childhood malnutrition doubles from the first to the second year of life. The prevalence of malnutrition varies among the provinces, and pockets of more severe malnutrition exist within the provinces. Micronutrient malnutrition is widespread, with rural areas being more adversely affected than urban areas. Female obesity is high, and it is more prevalent in urban than in rural areas.

An inadequate dietary intake is considered one of the major causes of micronutrient malnutrition. Food availability, accessibility and food choices and habits play a crucial role in food intake. Forced, limited food choices through lack of availability, accessibility and often nutritional knowledge result in a diet often characterised by sufficient quantity but poor quality. Steyn *et al.* (2006b) stated that it is unlikely that food fortification would fully compensate for a significant inadequate dietary intake, particularly in younger children who cannot eat large portions of fortified staple foods at a time. Eating rich sources of specific nutrients remains the only sustainable long-term solution. Many countries work towards the improvement of dietary diversification through home gardens and agricultural support. The ultimate aim should be to empower communities so that they can address the issues of under-nutrition through the utilisation of crops that are indigenous to their environment of their own accord.

The links between nutrition and agriculture are discussed in the next chapter.

CHAPTER 3

AGRICULTURE AND NUTRITION



INTRODUCTION

Agriculture is the basis of food security, which, together with maternal and child care and health services and environment, is a major factor impacting on adequate food intake (see figure 1.1). When the underlying cause of malnutrition is investigated, it becomes clear that agricultural interventions hold a key to addressing the problem of nutrient deficiencies, both in the short and long term.

This chapter reviews the links between agriculture and nutrition, using a gender sensitive approach. Constraints and measures to enhance the potential nutritional outcomes of agricultural interventions are also discussed.

3.1 FOOD SECURITY

> "*Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life*" (FAO, 1996).

Food security comprises a supply (needs of the consumer) dimension, which refers to nutritional adequacy, food safety and cultural acceptability, as well as a stability dimension, which refers to ecological, economical and social sustainability (see figure 3.1). Quantity and quality of food are both important. The quality of a food is a complex characteristic that determines its value or acceptability to the consumer. The attributes of quality include safety (which refers to the absence, or acceptable safe levels, of contaminants, impurities, natural toxins or any other substance that could be excessively or chronically damaging to health), nutritional value, organoleptic characteristics (such as appearance, colour, texture, taste) and functional properties (FAO, 2000:22).

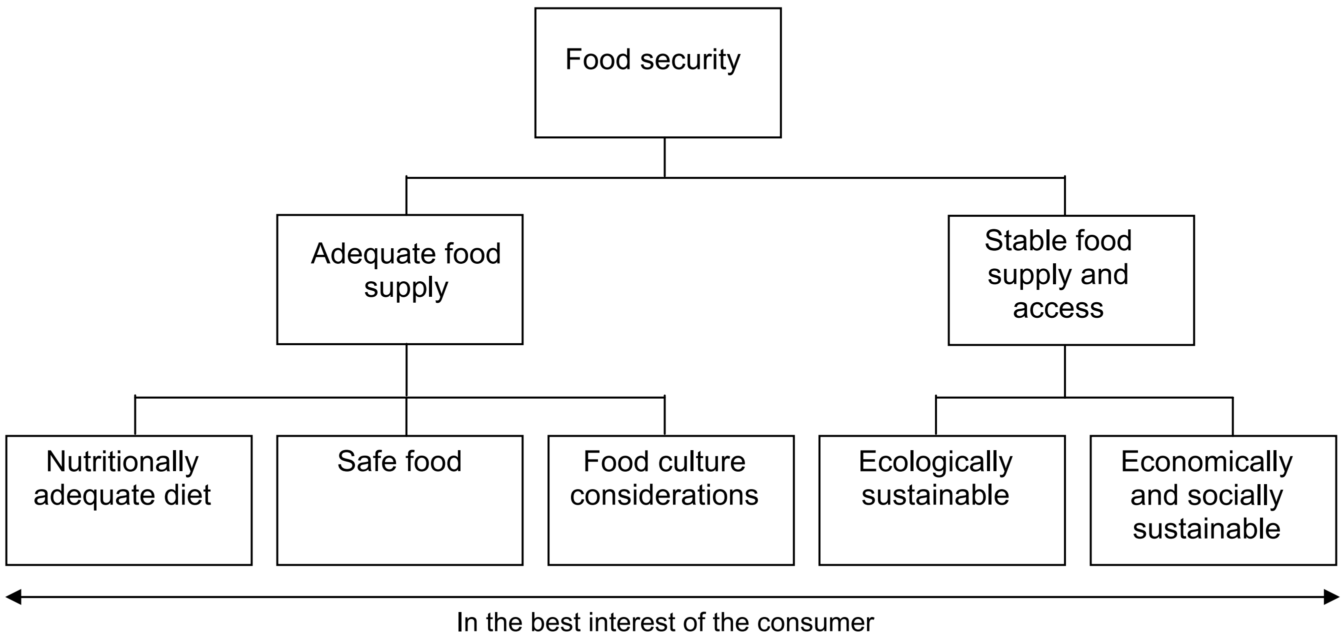


FIGURE 3.1: **THE FOOD SUPPLY AND STABILITY DIMENSIONS OF FOOD SECURITY**
Source: Oshaug & Haddad, 2002

Households can be defined as

(i) food secure
(ii) food insecure[1] without hunger[2]
(iii) food insecure with moderate hunger (food intake is reduced in adults, and adults are experiencing hunger because of resource constraints)
(iv) food insecure with severe hunger (children's food intake is reduced to an extent that implies that the children experience hunger as a result of inadequate resources within the household, while adults show evidence of more severe hunger).

(Bickel *et al.*, 2000:11-12).

It is important to note that within this context, both food insecurity and hunger result from resource constraints, other words, it is an involuntary lack of access to food (Bickel *et al.*, 2000:6).

The three basic elements of food security are

(i) food availability, which is achieved when sufficient quantities of food are consistently available,
(ii) access to food, which depend on adequate resources, and
(iii) utilisation of the food, which is the proper biological use of food (Riely *et al.*, 1999).

All three elements have to be present, and no one can sustain food security of itself. Food availability is necessary but insufficient to ensure food access, and food access is necessary but insufficient to ensure adequate food utilisation. For effective food utilisation, households need a diet providing sufficient energy and essential nutrients, potable water, and adequate sanitation. Knowledge within the household of food storage and processing techniques, basic principles of nutrition and proper child care, and illness management is therefore imperative (Riely *et al.*, 1999). Interventions to strengthen food security must ensure the complementarities and synergies between food availability, access and utilisation.

3.1.1 Food security in South Africa

The extent of food insecurity in South Africa and its major determinants have been reviewed in a position paper of the Human Sciences Research Council (HSRC) (De Klerk *et al.*, 2004: 27-34). Overall this report classified South Africa on the national level as being "food secure", based on the country's ability to be a net exporter of agricultural commodities. On the other hand it is stated that more than 14 million people (±35% of the population) may be vulnerable to food insecurity (De Klerk *et al.*, 2004:3).

Steyn *et al.* (2001a) used South African food balance sheets for 1998/99 supplemented with dietary surveys to determine changes in food security on national and household levels since 1993/94. They concluded that large sectors of the population are food insecure. Using Statistics South Africa's household-based 1995 Income and Expenditure Survey, and the national market-based Household Subsistence level for that period as tools for measuring food poverty, Rose and Charlton (2002) estimated the prevalence of food poverty around 43%.

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[1] Food insecurity can be defined as "limited or uncertain availability of nutritionally adequate and safe foods or limited or uncertain ability to acquire acceptable foods in socially acceptable ways" (Bickel *et al*, 2000:6).

[2] Hunger is defined as "the uneasy or painful sensation caused by a lack of food" and is a potential, although not necessary, consequence of food insecurity (Bickel *et al*, 2000:6).

In figure 3.2 a conceptual framework for food security is depicted illustrating that it involves many levels (ranging from a global- to an individual-level perspective) and aspects. This explains why prevalence figures are influenced by the perspective and indicators chosen.

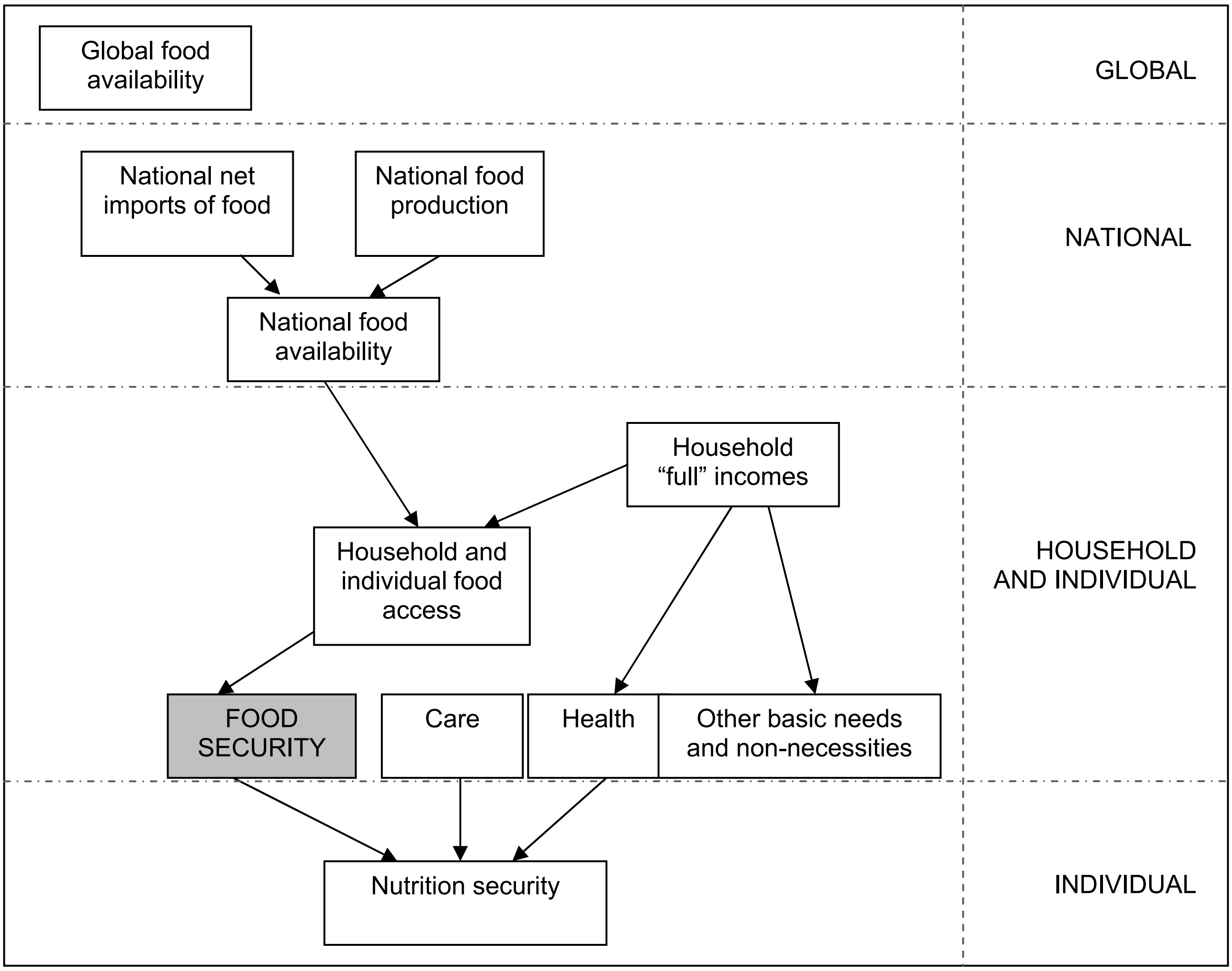


FIGURE 3.2: CONCEPTUAL FRAMEWORK OF FOOD SECURITY
Source: Smith *et al.*, 2000

The realisation that (household) food insecurity, regardless of how it is defined and measured, is rife in South Africa has resulted in many initiatives to redress the problem. In 2000 this led cabinet to formulate a national strategy to streamline, harmonise and integrate the diverse programmes into an Integrated Food Security Strategy (IFSS). The vision of the IFSS is to attain physical, social and economic access to sufficient, safe and nutritious food by all South Africans at all times to meet their dietary and food preferences for an active and healthy life. The goal of the IFSS is to eradicate hunger, malnutrition and food insecurity by 2015, indicating that South Africa is aligned to the MDG (even though being much more ambitious). One of the key food security challenges the country is faced with is to empower citizens to make optimal choices for nutritious and safe food (Department of Agriculture, 2002). This calls for collaboration between bodies that advocate proper nutrition and the agricultural sector.

3.2 LINKS BETWEEN AGRICULTURE AND NUTRITION

Agriculture can affect human nutrition in a number of ways. These impacts can be grouped into generic (not sector specific) and specific (generated because of food – not something else – being grown) effects as shown in table 3.1.

TABLE 3.1: GENERIC AND SPECIFIC EFFECTS OF AGRICULTURE ON NUTRITION

Generic effects	
Income generation	An increase in income enables individuals to diversify the diet and also to buy more non-foods, and this tends to imply a greater dietary quality. It is important not to equate increases in income with increases in nutrition.
Time allocation	The activities can affect the parents' time available for child care.
Household decision making	The activities can affect the bargaining power of household members, which can influence household decisions.
Energy and nutrient expenditure	The activities can affect the individual's energy and nutrient expenditure.
Health environment	The activities can affect the health risks within the environment.
Specific effects	
Decline in food prices	In general, increased food production will lead to lower food prices.
Own consumption	People's food consumption can be affected by what they grow.
Processing and preparation	Post-harvest activities such as storage, commercial and in-home processing and preparation can affect nutrient availability through (i) increasing the general use of nutrient-rich foods, (ii) increasing the nutrient density of foods consumed by infants, and (iii) decreasing nutrient losses from the processing of widely available foods.
Plant breeding	To increase the micronutrient content of the crop, decrease the concentration of absorption inhibitors such as phytic acid and increase the concentration of promoter compounds through traditional breeding and biotechnology.

Source: Haddad, 2000

Whilst food production and nutrition are intuitively linked, this relationship does not follow a direct course. In fact, the linkages have, over time, been summarised in many different conceptual frameworks, most of which depict the food system (also called food chain, food path or food pipeline), which starts with production (often, but not necessarily, on the macro level), followed by processing and distribution, and ends with food access and utilisation by individuals, typically measured in terms of nutritional status on the micro level. It is realised that any such framework may be an over-simplified representation of linkages, which suggests a linear relationship of cause and effect, and implies that a supply-driven approach would offer the solution. Figure 3.3 provides a schematic overview of the major links between agriculture and nutrition, as perceived by Mebrahtu *et al.* (1995). The primary reason for presenting a framework in this report is to emphasise that many factors are at stake. The framework given in figure 3.3 shows that agricultural activities may affect food consumption and nutrition through the following pathways:

(i) income of households with at-risk members, which, in turn affect child care, food preparation, and, in the longer run, sanitation, access to water, and use of primary health care
(ii) food prices (absolute, relative, and fluctuations)
(iii) time allocation, especially of women, which, in turn, influences child care, food preparation, and energy and nutrient expenditures

(iv) energy and nutrient expenditures

(v) exposure to diseases caused by changes in sanitation, access to water and living conditions associated with input use, technical change, resettlement, and other rural projects

(vi) changes in the nutritional composition of individual foods.

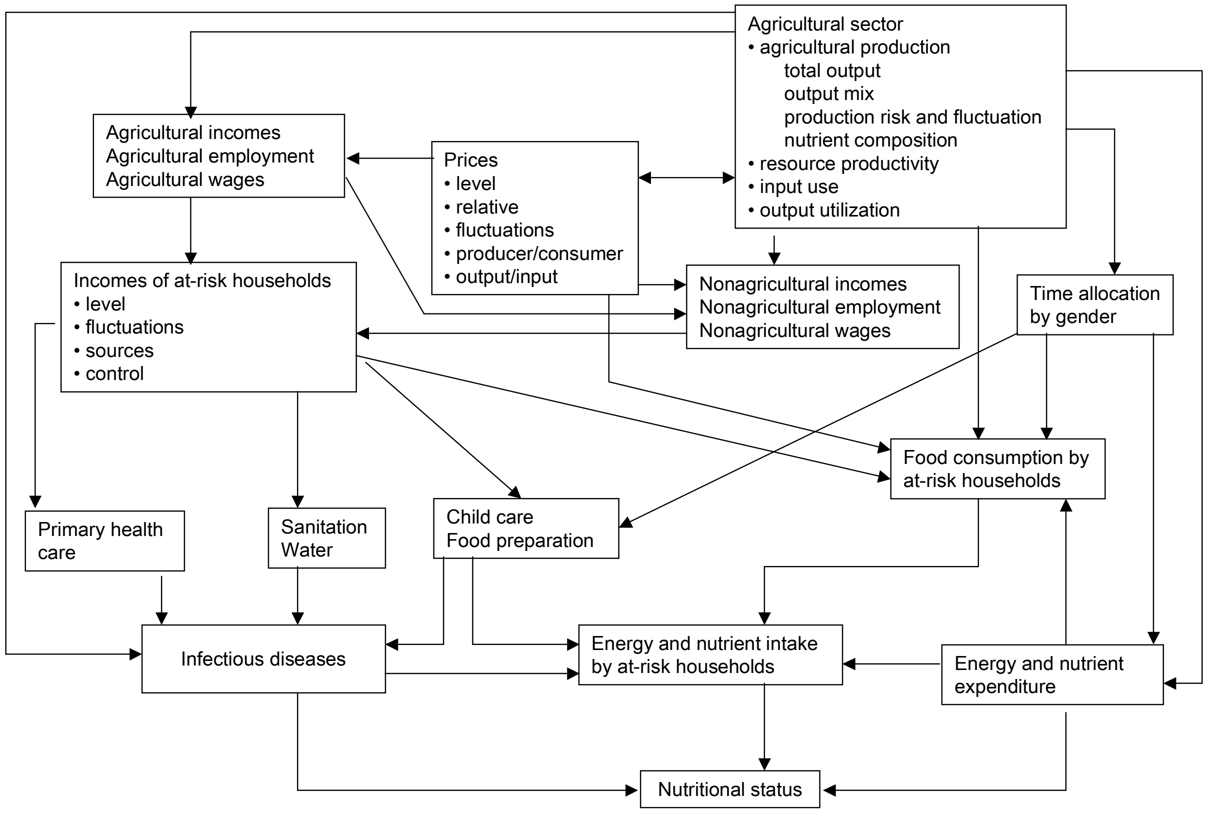


FIGURE 3.3: OVERVIEW OF MAJOR LINKS BETWEEN AGRICULTURE AND NUTRITION
Source: Mebrahtu *et al.*, 1995

Traditional efforts to reduce hunger and malnutrition using agriculture- or nutrition-based interventions alone fail to address the complexity and multiple causes of hunger, as well as the challenges men and women face as producers, consumers, and caregivers. The Agriculture-Nutrition Advantage framework (see figure 3.4), which is an expansion of the UNICEF conceptual framework for child malnutrition (see figure 1.1) took a new approach by linking agriculture and nutrition while accounting for gender (Johnson-Welch *et al.*, 2005). Agricultural activities can be divided into livestock production and crop production.

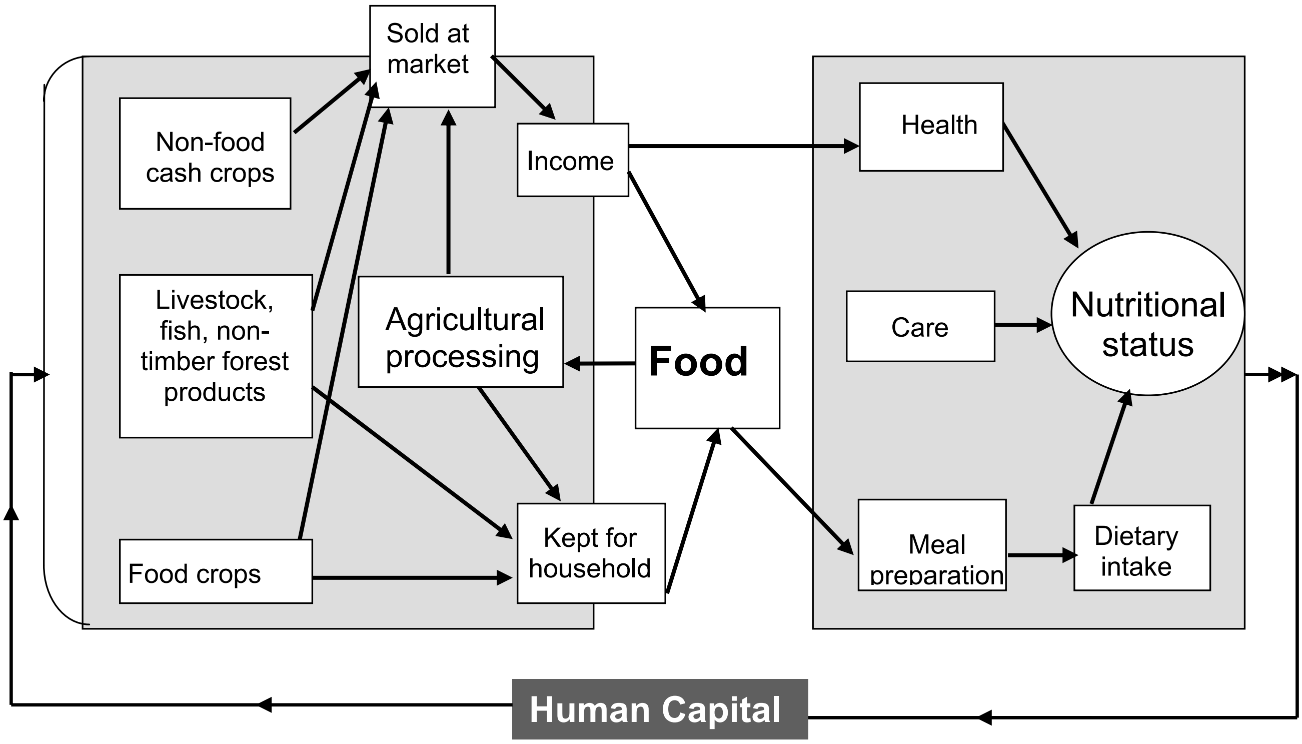


FIGURE 3.4: THE AGRICULTURE-NUTRITION ADVANTAGE FRAMEWORK
Source: Johnson-Welch *et al.*, 2005

3.2.1 Livestock production

3.2.1.1 Macro-livestock production

Among smallholders in South Africa, macro-livestock consists primarily of cattle, sheep and goats. These animals constitute a major tangible asset of an important proportion of rural African households in the country. In table 3.2 the 1995 distribution of these three types of livestock among the nine provinces is presented. To provide an indication of the livestock numbers held by African people the data were subdivided in accordance with the pre-1994 sub-division of South Africa in white commercial farming areas and former homelands and self-governing states. The year 1995 is the last for which this subdivision of livestock numbers is available. The data in table 3.2 assign livestock holdings of black people who lived outside the homelands to the category of white farmers. Consequently, the data presented underestimate the livestock holdings of black people in South Africa at the time of the census. This applies particularly to the Northern and Western Cape and to Gauteng.

In 1995, black farmers owned about 36% of the national cattle herd. Table 3.2 shows that African ownership of cattle was primarily concentrated in the Eastern Cape and KwaZulu-Natal. African smallholders in these two provinces held roughly a quarter of the national cattle herd. On a national scale, ownership of sheep by black farmers is less important than that of cattle or goats. In 1995, black farmers held 11.5% of the national sheep flock. The 1995 livestock census indicates that ownership of sheep by black people was essentially limited to the Eastern Cape Province. In South Africa, farming with goats is mainly an African enterprise. In 1995, black farmers held nearly two-thirds of the national goat flock, and ownership was fairly evenly distributed among the different provinces. The Eastern Cape was again the most important, followed by Limpopo Province, KwaZulu-Natal and North-West.

TABLE 3.2: DISTRIBUTION OF THE THREE MOST IMPORTANT MACRO-LIVESTOCK SPECIES IN SOUTH AFRICA IN 1995

Province	White farmers		Black farmers		All farmers	
	N	%	N	%	N	%
			Cattle			
Eastern Cape	897 457	10.7	1 753 397	37.7	2 650 854	20.4
Free State	2 000 803	23.9	18 112	0.4	2 018 915	15.5
Gauteng	255 594	3.1	0	0.0	255 594	2.0
KwaZulu-Natal	1 381 884	16.5	1 599 226	34.4	2 981 110	22.9
Limpopo	583 349	7.0	615 868	13.2	1 199 217	9.2
Mpumalanga	1 188 948	14.2	165 786	3.6	1 354 734	10.4
Northern Cape	458 088	5.5	0	0.0	458 088	3.5
North-west	1 136 565	13.6	499 557	10.7	1 636 122	12.6
Western Cape	460 711	5.5	0	0.0	460 711	3.5
Total	**8 363 399**	**100.0**	**4 651 946**	**100.0**	**13 015 345**	**100.0**
			Sheep			
Eastern Cape	4 964 517	19.5	2 794 900	84.6	7 759 417	26.9
Free State	5 968 442	23.4	5 740	0.2	5 974 182	20.8
Gauteng	115 445	0.5	0	0.0	115 445	0.4
KwaZulu-Natal	908 593	3.6	124 288	3.8	1 032 881	3.6
Limpopo	95 199	0.4	82 856	2.5	178 055	0.6
Mpumalanga	2 074 669	8.1	6 096	0.2	2 080 765	7.2
Northern Cape	7 421 077	29.1	0	0.0	7 421 077	25.8
North-west	488 275	1.9	288 779	8.7	777 054	2.7
Western Cape	3 445 450	13.5	0	0.0	3 445 450	12.0
Total	**25 481 667**	**100.0**	**3 302 659**	**100.0**	**28 784 326**	**100.0**
			Goats			
Eastern Cape	1 319 010	55.7	1 898 906	46.6	3 217 916	49.7
Free State	62 097	2.6	9 040	0.0	71 137	1.1
Gauteng	12 950	0.5	0	0.0	12 950	0.2
KwaZulu-Natal	113 198	4.8	710 493	17.4	823 691	12.8
Limpopo	50 636	2.1	890 104	21.8	940 740	14.6
Mpumalanga	33 443	1.4	47 544	1.2	80 987	1.3
Northern Cape	432 481	18.2	0	0.0	432 481	6.7
North-west	83 681	3.5	531 348	13.0	615 029	9.5
Western Cape	261 856	11.2	0	0.0	261 856	4.1
Total	**2 369 352**	**100.0**	**4 087 435**	**100.0**	**6 456 787**	**100.0**

Source: Department of Agriculture, 1995

3.2.1.1.1 Cattle

Cattle ownership among rural African households is fairly widespread, but the average herd size tends to be small, amounting to between five and twelve head per owner. The distribution pattern in terms of herd size reflects a large majority of households with a few animals and a small group that owns many (Bembridge, 1979; Tapson & Rose, 1984:15-16; Düvel & Afful, 1997; Ntshona & Turner, 2002; Ainslie, 2002; 2003). Relative to commercial herds, the composition of smallholder herds is characterised by a high proportion of oxen and a low proportion of cows and heifers (Bembridge, 1979; ARDRI, 1987:27-28). Genetically the herds are heterogeneous. This is the result of efforts by the state to introduce “improved sires” and smallholders purchasing cattle from their large-scale counterparts (Bembridge, 1979, ARDRI 1996, Ainslie, 2003).

African farmers keep cattle for multiple reasons, including utilitarian, investment, religious, cultural and social. Reasons vary among farmers, are influenced by local conditions, and evolve over time (Düvel and Afful, 1997, Kepe, 2002).

Obtaining milk for home consumption is an important reason why black people keep cattle from a nutritional perspective (Tapson & Rose, 1984:33; Monde, 2003:110). Lactating cows are awarded priority status when crop residues are available, but few farmers actively feed their lactating animals (Bembridge, 1984:373; Tapson & Rose, 1984:119; Steyn, 1988:380; Bennett, 2002:chapter 4).Generally, lactating cows in smallholder herds do not produce much milk. Indications are that lactating cows in good condition produce on average approximately 6 L of milk per day over a period of 8 months (Brown, 1969:127). Of the total production, half is needed to nourish the calf, leaving approximately 3 L/day for human consumption. The available estimates indicate that average milk yields for home consumption or sales range between 1.7 L and 2.3 L per lactating animal per day (Tapson & Rose, 1984:37-38 citing Gandar & Bromberger, 1984; Bembridge, 1984:367; Steyn, 1988:346). Tangka *et al*. (2000) provide evidence from several studies in different parts of the world that the regular intake of cows' milk has a positive effect on the nutritional status of children in developing countries. Home slaughter of cattle is another practice that can potentially impact on human nutrition, but home slaughter of cattle among black people in South Africa is almost exclusively associated with ceremonies and rituals that are linked to ancestral beliefs. This results in the carcass being consumed by large numbers of people, spreading the nutritional benefits widely but thinly. Cultural practises determine who eats what and when, illustrating the potential impact of intra-household and intra-community distribution of food on the actual dietary intake of the individual.

3.2.1.1.2 Sheep

Smallholder production of sheep is essentially limited to the Eastern Cape. Relative to cattle and goats, ownership of sheep among rural households in the Eastern Cape is less common (29% overall), but the average number of animals per keeper is substantially higher (18 animals) (Van Averbeke & Silwane, In Press). In the smallholder sheep-production sector of the Eastern Cape the animals are primarily kept for two purposes, namely meat and wool. Milking of sheep is rare. Local smallholders more easily consume a sheep for the purpose of eating meat than is the case with cattle or goats. As a result, a major portion of the value derived from sheep is in the form of meat for home consumption. In 1980, in the Transkei region Bembridge (1984:384) reported gross value in sheep production to consist of sales of animals (9.6%), meat consumption (77.8%) and wool sales (12.6%). At two sites in the Ciskei region these contributions were 27.7% from sales of animals, 35.5% from meat consumption and 36.8% from sales of wool (Steyn, 1988:404).

3.2.1.1.3 Goats

In many parts of the world, including South Africa, goats are referred to as the poor man's cattle (Mafu & Masika, 2002). It is said that when livestock are compared with money, cattle are the bills and goats the coins (Ainslie, 2003). In several ways goats play a similar role as cattle. They are favoured for ritual slaughter, because as with cattle they make a lot of noise during the kill, calling on the ancestors. Goats are also milked, although opinions about the taste of goats' milk vary from person to person (Mafu & Masika, 2002). In some African rural communities milking of goats is viewed as an indication of poverty (ARDRI, 1996). Reported average milk yields from goats are 300 – 700 mL/day in the Eastern Cape (Mafu & Masika, 2002) and 200–1000 mL/day in the tropics (Peacock, 1996:264).

3.2.1.2 Micro-livestock production

Production of micro-livestock, mainly in the form of poultry, usually chickens, and to a lesser extent pigs, is very common among African rural households in South Africa. A review of six studies conducted in different parts of the Eastern Cape indicated that 76% of rural households kept chickens, and nearly six out of ten kept pigs (Van Averbeke & Silwana, In Press). Other species of micro-livestock that are kept include rabbits (Sonandi, 1995), geese (ARDRI, 2001:45), pigeons, ducks and guinea fowl (Delanote, 2001:34), but compared with chickens and pigs these species are rare.

3.2.1.2.1 Chickens

The prevailing way in which African households in the rural areas of South Africa and in Africa at large produce chickens may be referred to as the scavenger system. During the day they roam freely around human settlements, whilst at night they are usually locked up for security reasons (Smith 1990:179). The food they obtain from the land is often supplemented with leftovers from homestead meals and poor-quality grain in cases where keepers are involved in grain production (McAllister, 2000:12). The scavenger system is efficient in the sense that input levels are very low or non-existent, making it ideally suited for poor rural people. Production levels are also low, and the availability of food limits the total number of birds that can subsist within a particular settlement. For example, in the Eastern Cape four out of every five households that kept chickens possessed 10 birds or less. In most cases chickens produced by means of the scavenger system are dual-purpose, supplying both meat and eggs. They are primarily produced for home consumption, but occasional sales are not exceptional (Van Averbeke & Silwana, In Press). The meat of scavenger chickens is considerably tastier and chewier than that of chickens produced in broiler units, a quality highly appreciated by African consumers (Smith, 1990:46). It is estimated that scavenger chickens produce between 20 and 30 eggs per year, of which most are left to hatch because they are not found in time (Smith, 1990:179-180). The majority of chicks that are hatched die. Smith (1990:182) reports a mortality rate of 80% in scavenger systems in Nigeria and Sudan. If it is assumed that the population of scavenger chickens in a settlement represents a biological maximum for the food that is available (an assumption that needs testing) the data provided by Smith (1990) suggest that reproduction in a scavenger system allows for an annual off-take of about one-third of the birds. In other words, every year 33 out of 100 scavenger chickens can be consumed or sold without causing a decline in the total population.

3.2.1.2.2 Pigs

Many rural households keep a few pigs which they rear by means of a scavenger system. Among rural people in South Africa the keeping of pigs appears to be less common than that of poultry, even in rural communities, such as in the Eastern Cape, where there apparently are no taboos associated with the consumption of pigs. Here an estimated 56% of households keep an average of 2 pigs at a time (Van Averbeke & Silwana, In Press). In areas such as the Venda region of the Limpopo Province, where religious taboos against the consumption of pork exist, the proportion of households keeping pigs is lower than in the Eastern Cape. Home-slaughter of livestock is common among rural households, but the selling of meat of slaughtered animals is not. Pork is the main exception. For example, in the Eastern Cape, pigs are the only livestock species that rural people slaughter for the purpose of selling meat. Selling pigs live or using the meat for home consumption are also common practices (Steyn, 1988: 442; Mafu, 1998).

3.2.2 Crop production

Greater and more sustained yields may increase the potential access of households to a larger food supply and therefore a more adequate diet. However, greater yields do not ensure that all households or every household member has access to that food. In South Africa, food supplies at national level are adequate to feed the entire population, yet household food insecurity is widespread (Rose & Charlton, 2002; Steyn *et al.*, 2001a).

Greater yields through mono-crop production of low nutrient content crops do not necessarily translate into adequate nutrition. Diversification of crops will help communities to be more self-reliant in respect of nutritional problems. Increasing the variety of foods in the diet across and within food groups is recommended internationally, and dietary diversity is recommended as an objective to be included in each country's food-based dietary guidelines (FAO/WHO, 1998). Enjoying a variety of foods has been recommended in the South African food-based dietary guidelines (Maunder *et al.*, 2001). Results of the NFCS showed that the diets of many South African households have low dietary variety, particularly those households with a low income (Labadarios *et al.*, 2000). Achieving the goal of dietary diversity will be most difficult for low-income households because of the constraints of poverty. Affordability has been identified as a major constraint, particularly with regard to fruit and vegetable consumption (Love *et al.*, 2001). Availability of fruits and vegetables is also a constraint affecting dietary diversity (Love *et al.*, 2001). The availability of a greater variety of nutritious foods at community and household level can be increased through (i) mixed cropping, (ii) the introduction of new crops, (iii) the promotion of underexploited traditional food crops; and (iv) home gardens (FAO, 1997:chapter 5).

3.2.2.1 Mixed cropping

The promotion of mixed cropping can increase the availability of a greater variety of nutritious foods, extend the harvesting period and help alleviate seasonal food shortages. It is also associated with potential yield improvements and reduced risk of crop failure (FAO, 1997: chapter 5).

3.2.2.2 Introduction of new crops

Where the purpose of agricultural activities is to improve the nutrient intake of vulnerable groups, local food habits and the nutrient content of the crop and its potential contribution towards the nutritional requirements of the target population are predominant considerations in the selection of crops to promote. Breeders, agronomists and nutritionists should collaborate to evaluate potential nutritional attributes of the crops (FAO, 2001).

Crops selected for agricultural interventions should be easy to grow and cook, and be palatable (Chakravarty, 2000). Consumer preferences in terms of the characteristics of the crop, e.g. colour, dry-matter content, texture and flavour, are important. In Kenya, for example, adults preferred orange-fleshed sweetpotato varieties with a high content of dry matter whereas children preferred weaning foods made from varieties with a low content of dry matter (cited in Hagenima & Low 2000).

In general acceptability of specific foods is reflected by cultural preferences, affordability, and possibly the effectiveness of education and the media in respect of the vulnerable population. Foods promoted in agricultural interventions that aim to address the nutritional status of the target population need to be available for an acceptable amount of personal time and energy expenditure, or for an affordable cost within the household or personal income structure. Foods that are unfamiliar must be introduced with education or media techniques in ways that make the foods culturally acceptable to the community and the individual, and the people should be convinced that they need it (Kuhnlein, 2000).

Crops grown by women, especially vegetables, are normally consumed by household members (FAO, 2001) and should therefore be considered as important crops to be promoted in agricultural interventions (Hagenimana *et al.*, 2001). Sweetpotato is an example of a woman's crop.

A study in the Eastern Cape showed that most of the capital cost for home gardens is spent on buying seeds (Mabusela, 1999). Using crops that can be vegetatively propagated, e.g. sweetpotato, is not only cheaper but also easy to multiply and distribute (Bonnard, 1999).

Most studies with plant foods focused primarily on vitamin A status. Vitamin A in plant foods is present in the form of provitamin A carotenoids, mostly β-carotene. Provitamin A carotenoids achieve vitamin A activity when they are converted into retinol in the body. Dark-green leafy vegetables, yellow/orange non-citrus fruit and yellow/orange-fleshed vegetables are good sources of provitamin A carotenoids. A study among Chinese children showed that plant provitamin carotenoids from green and yellow vegetables can sustain vitamin A status (Tang *et al.*, 1999). Although fruit, dark-green leafy vegetables and carrots are less effective as sources of vitamin A than previously assumed (De Pee *et al.*, 1998), consumption of cooked and pureed green leafy vegetables (Takyi 1999; Haskell *et al.*, 2004; Haskell *et al.*, 2005), sweetpotato (Jalal *et al.*, 1998; Haskell *et al.*, 2004; Van Jaarsveld *et al.*, 2005) and carrots (Haskell *et al.*, 2005) has been shown to improve vitamin A status.

Dark-green leafy vegetables contain relatively large amounts of iron, yet agricultural interventions to increase the supply and intake of iron from plant foods are not popular (Ruel, 2001). The potential of plant foods to control iron deficiency in developing countries has been questioned (De Pee *et al.*, 1996). The bioavailability of non-heme iron in plant foods is low, and plant foods often contain a variety of compounds such as tannins, phytates, and polyphenols that inhibit the absorption of non-heme iron. Food-based approaches targeting iron intake or improved iron status usually encourage the production and consumption of animal foods because of the high bioavailability of heme iron in animal foods (Ruel, 2001).

3.2.2.3 Traditional food crops

Agricultural interventions should aim to increase the use of under-exploited natural resources such as traditional food crops. (FAO, 1997: chapter 5). Indigenous vegetables require minimum production input, and moreover people are accustomed to them and know how to cultivate and prepare them. African leafy vegetables grow quickly and can be harvested within a short period of time. It grows on soils of limited fertility; is relatively drought tolerant, provides good ground cover, and is usually cultivated without pesticides or fertilizers (Shiundu, 2002). Women usually play a major role in the collection and preparation of wild leafy vegetables (Modi *et al.*, 2006).

The NFCS showed that green leafy vegetables were the 16th most frequently consumed food item for 1-9-y-old South African children (12% of the children consumed it during the recall period). The highest consumption was in Limpopo (previously known as the Northern Province), with green leaves being the 4th most frequently consumed food item with 46% of the children consuming it during the recall period (see table 2.18). A smaller study in Limpopo showed that green leafy vegetables were the 5th most frequently consumed food item of the adult population (Steyn *et al.*, 2001b). The edible wild green leafy vegetables are known as *miroho, morogo* or *imifino*, which freely translated means leafy vegetables. The plant parts that are eaten include leaves, flowers, seeds, or a combination of these (cited in Nesamvuni *et al.*, 2001). Frequent consumers of wild green leafy vegetables in Limpopo were shown to eat it at least once or twice a week, and the cooked portion sizes commonly ranged from 45–105 grams to 180–270 grams (Nesamvuni *et al.*, 2001; Steyn *et al.*, 2001c). *Amaranthus hybridus* L. and *Amaranthus thunbergii* were the most commonly eaten plants (Steyn *et al.*, 2001c). In Venda (the most northerly region of Limpopo) the leaves are mainly harvested during summer and the surplus is stored in either a dried-cooked or dried-raw form for at least six months (Nesamvuni *et al.*, 2001).

In Venda collection of wild plants takes place throughout the year, traditionally by women (cited in Nesamvuni *et al.*, 2001). A study in Ezigini, a rural community in KwaZulu Natal, showed that wild leafy vegetables are available in abundance from November to April (Modi *et al.*, 2006).

Modi *et al.* (2006) stated that cultivated lands are more suitable for the growth and development of wild leafy vegetables, and the availability of these could therefore be enhanced by cultural practices associated with crop management. Liphadzi (2006) of the Agricultural Research Council argued that production of wild leafy vegetables in home gardens or availability thereof in local markets would be advantageous.

Faber et al. (2007) reported that dark green leafy vegetables (a combination of spinach and *imifino*) contributed significantly to dietary intake of calcium, iron, vitamin A and riboflavin of 2-5-y-old children in an area where consumption of these vegetables was promoted. It is however difficult to determine the nutritional contribution of specific wild leafy vegetables to total dietary intake because of the lack of compositional data. There is a lack of information on energy and micronutrient composition of dietary wild plants, especially for Africa, and a need for improved nutritional databases to allow quantified evaluations of the local regional diet (Givetti & Ogle, 2000). Nesamvuni *et al.* (2001) collected and analysed the ten most commonly consumed wild green leaves eaten in Venda, and some of these values are incorporated into the 1998 edition of the South African food composition tables (Kruger *et al.*, 1998). Nesamvuni *et al.* (2001) collected only one sample for each type of leaf from one site. Food samples are typically heterogeneous and as a result a bigger sample size is usually needed to obtain a representative sample (Rodriguez-Amaya, 1999). It is preferable that the nutritional content of indigenous foods is measured after cooking/processing to reflect the nutritional composition of the food as eaten.

Dark green leaves are good sources of various nutrients (e.g. Fe, Ca, Zn and β-carotene), but bioavailability of these nutrients can be an issue because dark-green leafy vegetables contain compounds such as oxalates, phytates and nitrates that reduce the absorption of certain nutrients (De Pee *et al.*, 1996).

Promoting indigenous crops may be difficult. Many people are not aware of the nutritional value of wild green leafy vegetables (Steyn *et al.*, 2001c). Traditional food crops (e.g. green leafy vegetables) are often regarded as inferior (Steyn *et al.*, 2001c) and seen as the “poor person’s food” (FAO, 1997: chapter 5). Quantitatively, the consumption of leafy vegetables collected from the wild tends to be inversely proportional to household income (Vorster *et al*., 2002). Unpopularity and unavailability were given as possible reasons for the low consumption of indigenous vegetables (pumpkin leaves 3%; dried green cowpea leaves 3%) observed among college students in Limpopo province (Mbhenyane *et al.*, 2005). There is a need for vigorous marketing of green leafy vegetables as a status symbol (Machakaire, 2001). Campaigns promoting these vegetables should focus on the younger generation, as they have less knowledge of wild green leafy vegetables (Modi *et al.*, 2006).

3.2.2.4 Home gardens

Home gardening has been shown to be an important way to improve the intake of vitamin A-rich foods, particularly for poor households and in countries where plant foods are the main source of vitamin A (Talukder *et al.*, 2000). Berti *et al.* (2004) reviewed papers published between 1985 and 2001 on the impact of agricultural interventions on nutritional status. Among the projects reviewed, home-gardening projects had a higher success rate than other types of agricultural interventions. Two possible explanations for this were given, namely, (i) home-gardening is an inherently strong intervention, which most households can adopt, and (ii) all the home-garden projects strengthened human capital through nutrition education and/or gender considerations.

In developing countries home gardens are usually established to increase household production of fruits and vegetables as a way of supplementing the cereal-based diet of rural households. The main objective of home-garden projects is to improve both household food supply and dietary quality (usually in terms of micronutrients). Few home-garden projects have the objective to increase household income (Ruel, 2001). This is also the case in South Africa, as was shown in a study in the Eastern Cape, where the main purpose of home gardens was to produce crops for household consumption (Mabusela, 1999).

In a review by Ruel (2001) it was concluded that compared with home-garden projects that were carried out in the 1980s and which did not include education activities, the new generation of integrated production and education projects have been much more successful in improving knowledge, awareness, attitude, and practices related to vitamin A (Ruel, 2001). In South Africa, the Ndunakazi project is an example of such an integrated approach (Faber *et al.,* 2002a, 2002b).

The Ndunakazi integrated home-garden and growth monitoring project was developed, monitored and evaluated during the 1990s by the Medical Research Council (MRC), with ARC-Roodeplaat as agricultural partner in a rural village in KwaZulu-Natal. Nutrition education was given during community-based growth monitoring sessions. Demonstration gardens within the village were used as training centres for crop production. Before implementation of the garden project the children consumed a cereal-based diet that was low in vitamin A (Faber *et al.*, 2001). The garden project resulted in improved maternal knowledge of vitamin A nutrition (Faber & Benadé, 2003). The intake of yellow/orange-fleshed and dark-green leafy vegetables increased, and as a result the intake of vitamin A and various other essential micronutrients (e.g. calcium, iron and vitamin C) increased (Faber *et al.*, 2002a). This had a positive effect on the vitamin A status of the children, as reflected in higher mean serum retinol concentrations (Faber *at al*, 2002b).

3.2.3 Nutrition

While both men and women are engaged in agricultural production, marketing and post-harvest processing, and earning income, women and girls tend to have the primary responsibility for family nutrition. Nutritional interventions generally focus on increasing knowledge, changing attitudes, and improving practices related to the three pillars of good nutrition, namely health, care, and dietary intake. They tend to target women as the primary caregivers, although recognition of men's roles in family health and nutrition is increasing (Kurz & Johnson-Welch, 2001).

Nutrition education can stimulate the demand for certain foods, but the individuals must have the means and opportunities to act on that knowledge. In the Ndunakazi project, caregivers of all the children were exposed to nutrition education, regardless whether they had a project garden or not. Yet children from households with project gardens had a better vitamin A status than children who did not have a project garden at household level (Faber *et al.*, 2002b). This suggested that access to a supply was critically more important than education without ready access.

The bioavailability of nutrients in food is influenced by factors such as the type and extent of processing, and the influence of other dietary components. These factors can be controlled by the caregiver and should therefore be addressed through nutrition education. Examples of such factors related to vitamin A nutrition are:

(i) *Raw versus cooked*: Rock *et al.* (1998) showed that the bioavailability of β-carotene in processed carrots and spinach is higher than in the raw vegetables.

(ii) *Presence of fat in the meal*: Brown *et al.* (2004) showed almost no absorption of carotenoids when salads with fat-free salad dressing were consumed. A substantially greater absorption of carotenoids was observed when salads were consumed with full-fat than with fat-reduced salad dressing. Jalal *et al.* (1998) showed a beneficial effect when adding fat to a meal that contained β-carotene sources (mainly red sweetpotato). Unlu *et al.* (2005) showed that adding avocado fruit (which has a high fat content) to the meal could significantly enhance carotenoid absorption.

(iii) *Deworming*: Deworming has a beneficial effect on the bioavailability of provitamin A carotenoids (Jalal *et al.*, 1998; Takyi, 1999).

Interventions to increase dietary fat concentrations and anthelmintic treatment should be considered along with food-based interventions that focus on increasing consumption of β-carotene-rich food to address vitamin A deficiency.

3.2.4 Gender

Using a gender-sensitive approach strengthens the link between agriculture and nutrition (Johnson-Welch, 2001). Projects that, among other, consider gender issues have a greater likelihood of effecting a positive nutritional change (Berti *et al.*, 2004). The term gender refers to differences between men and women that derive from social and cultural norms and expectations (Johnson-Welch, 2001). In comparison the term sex refers to the physical and biological differences between men and women (Jiggins *et al.*, 1997). Opportunities to link agriculture and nutrition by addressing gender-related factors is often missed because of a lack of understanding of how to apply gender methodologies to the design and implementation of interventions (Levin *et al.*, 2003).

In the link between agriculture and nutrition, gender analyses will take into account factors such as women's roles as agricultural producers and caregivers, their time and labour allocation, and their decision-making roles relative to the use and distribution of resources and benefits within the household (Johnson-Welch *et al.*, 2005). For example, in Uganda a gender-informed approach was used to identify preferred agronomic characteristics of beans. Men preferred varieties that were high-yielding with market value, while women, because of their time and labour constraints, preferred varieties that were easier to process (cited in Johnson-Welch *et al.*, 2005).

Men's and women's participation in the agricultural production process must be analysed along two related dimensions: their role in agriculture and their role in the household (Jiggins *et al.*, 1997). Gender analysis can be used to identify power relationships between men and women within a household and in their communities, their motivations and perceptions regarding their own and others' roles and responsibilities, and the decisions they make about allocation of resources and benefits (Johnson-Welch, 2001).

The responsibilities and privileges of men and women vary along socio-cultural and socio-economic lines specific to a particular time and place. It is thus misleading to make assumptions about the particular patterns in gender relationships in any one household on the basis of data from elsewhere. Even within one country generalizations are not advisable. Rural women should not be viewed as a homogeneous social classification, and policies and services for women and agriculture should be based on empirical research that captures the diversity. Agricultural extension services need to be adapted to circumstances rather than designed on the basis of a single universal model (Jiggins *et al.*, 1997).

It is important to invest in people by building their capacities to solve problems, access technologies and other resources, and control the allocation of benefits that derive from resource use. Agricultural policies and programs of the past failed to address women's production-oriented constraints, including their lack of access to and control over assets and resources. For example, women in Africa have always had limited access to formal information and communication systems associated with agricultural development. This was partly due to the imposition of an extension service with a philosophy, organizational structure and management system that are rooted in western cultural traditions whereby women are recognised as home managers. By contrast, women in Africa are *both* home managers and producers of food. This difference in the roles of African and European women was not taken into account when extension services were being established in African countries (Hafkin & Taggart, 2002).

Daily constraints of the caregiver include financial, time and cultural constraints (Hagenimana & Low, 2000). Agricultural activities that reduce women's time constraints can contribute to family nutrition. In Tanzania, for example, the use of solar dryers improved labour productivity of women and children because they could leave the area to do other things, whereas the traditional method of drying required their presence to keep animals and insects away from the food (Mulokozi *et al.*, 2001).

3.3 CHALLENGES IN LINKING AGRICULTURAL INTERVENTIONS TO NUTRITION

Data from Ghana, Mozambique, Nigeria and Uganda showed that (i) nutrition is invisible in political decision making; (ii) the role of nutritional specialists in influencing policy making has been marginal; (iii) nutrition is everyone's problem but no one's responsibility; and (iv) everyone "knows" gender, but they don't know what to do with it. Although nutrition cuts across sectors, nutritionists tend to work in Ministries of Health, where malnutrition is often viewed as a disease that is treatable by means of biomedical interventions such as vitamin capsules. An integrated approach is often hampered because institutions operate in a vertical fashion, denying agriculturalists and nutritionists opportunities to collaborate. Funding streams follow the same vertical pattern. Consequently each sector is reluctant to use its scarce resources for activities that might seem to be another's responsibility (Levin *et al.*, 2003). Often agricultural interventions measure impact in terms of economic growth, and discuss food security in terms of increased availability of and access to food, without taking food consumption into consideration (Bonnard, 1999).

A study that explored the views of a multinational cross-disciplinary group of stakeholders on the potential for gender-sensitive agricultural and nutritional strategies to reduce malnutrition showed that there was general agreement on the value of linking agriculture, nutrition and gender. However, there was less consensus and sustained commitment on how to promote such strategies (Levin *et al.*, 2002). Action-orientated strategies should go beyond the question of "why" an agriculture-nutrition-linked, gender-informed approach should be used, to "how" it could be implemented (Johnson-Welch *et al.*, 2005). Measures to enhance the potential nutritional outcomes of agricultural interventions are listed in table 3.3.

TABLE 3.3: MEASURES TO ENHANCE THE POTENTIAL NUTRITIONAL OUTCOMES OF AGRICULTURAL INTERVENTIONS

Agricultural projects must focus on specific nutritional problems

Agricultural projects must assist nutritionally vulnerable groups to grow crops to meet their nutritional needs. The focus should be on nutrients that are limited in their diets, which can be defined through nutritional status and food consumption surveys. Nutritional outcomes must be clearly defined. Nutrition experts should collaborate with agronomists and contribute to the planning, implementation and evaluation of community-based agricultural interventions, based on the food needs and nutritional requirements of community members. This will make the projects more demand-driven and consumer-focused.

Conceptual framework

A conceptual framework that lays out the pathways between nutrition and agriculture should be used to guide the design, implementation and evaluation of the project.

Multidisciplinary team

Partners with complementary skills should work together toward a common goal. When working across disciplines, individuals must be sensitised to the terminology, concepts and priorities of the other disciplines.

Promote indigenous food crops

People are accustomed to them, and know how to cultivate and prepare them.

Diversify food production

The availability of a greater variety of nutritious foods at community and household level can be increased through (i) mixed cropping, (ii) the introduction of new crops, (iii) the promotion of under-exploited traditional food crops; and (iv) home gardens.

Expand the seasonal availability of food

This can be achieved through staggered planting, processing and preserving.

Promote vegetatively propagated crops

Crops that are vegetatively propagated reduce money spent on seeds and are easy to multiply and distribute. Local seed multiplication brings seed closer to farmers and creates employment. This needs good managerial and quality control.

Agricultural and health extension agents

Nutrition-focused components need to be included in the training and work agendas of both agricultural and health extension agents. Extension agents should know more about, and provide information on, gardening and nutrition, especially in relation to the crops, technologies, and practices.

Processing

Improved processing and storage of fruits and vegetables can reduce waste and post-harvest losses, extend seasonal availability and generate employment. It is important to use appropriate processing methods to minimize nutrient losses.

Participatory process

Using a participatory process effectively creates the opportunity to bring a wide range of people into the decision-making process involving the planning, implementation, monitoring and evaluation of the project. Hunger and under-nutrition are most visible at the individual and household levels; community input is therefore invaluable, putting a human face on the problem. Involving women in the participatory process will ensure that their needs and concerns are considered, and that project activities do not become a burden to them. Involvement of farmers in the participatory process will ensure that indigenous knowledge complements formal scientific knowledge.

Involve women

Involving women in the design stage, or working directly with them on implementation issues greatly increases their participation, and ultimately the achievement of program objectives.

Nutrition education

Nutrition education is of central importance for achieving nutritional improvement through agricultural interventions. Nutrition education is crucial to ensure that increased food supply translates into improved dietary quality. Nutrition education should either be part of the agricultural project or be done through collaboration with other development activities. Social marketing techniques should be used extensively, including men and other community members – not only the target population. Nutrition messages should be tailored to the community's needs and should relate to the agricultural intervention.

Table 3.3 continues on the next page

TABLE 3.3: MEASURES TO ENHANCE THE POTENTIAL NUTRITIONAL OUTCOMES OF AGRICULTURAL INTERVENTIONS *(continued)*

Measure impact
Use various research methods to show impact. For example, use qualitative and quantitative data collection methods in an iterative fashion; select an outcome indicator that is sensitive to the intervention, including changes in agricultural production; and compare results within and across control and experimental groups over time.
Evaluate sustainability
Berti *et al.* (2004) reviewed papers published between 1985 and 2001 and concluded that those projects that invested broadly in human and other types of capital had a greater likelihood of effecting a positive nutritional change, but it was not clear what is necessary to sustain the nutritional benefits in the years after the intervention period.

Sources: FAO, 1997:chapter 5; Bonnard, 1999; FAO, 2001; Hagenimana *et al.*, 2001; Ruel, 2001; Berti *et al.*, 2004

3.4 AGRICULTURE IN RURAL SOUTH AFRICA

Agricultural activities have become a major avenue for providing an alternative means of supplementing family income in rural areas in South Africa (Ngqaleni & Makhura, 1995). Over one third of rural households continue to engage in agricultural production, making it the third most important livelihood tactic used in rural areas after remittances and wages from low-skilled jobs (Machethe, 2004). Thus agriculture qualifies as one of the most important sources of subsistence among rural families, and the role of women in agriculture has also grown significantly. Because the traditional gender-based division of labour has broken down, rural women have taken over the tasks previously undertaken by men. This has added greatly to their already high workload. Women also have to perform multiple tasks to sustain their households. These tasks are not only time-consuming but are made more difficult by a lack of capital and the absence of basic infrastructure and services (Rossouw, 1996). This underlines the importance of targeting women (especially rural women) in agricultural training programmes.

Food production forms the basis of household food security. Food insecurity is an important underlying cause of malnutrition (figure 3.2). Food production can take place on household level, particularly in rural settings, but more commonly it takes place on community, national or even international level. From a macro-level perspective, Gerbens-Leenes and Nonhebel (2004) claim that the expected growth of the world population and the increase of per capita food demands may require a doubling of current global food production. Food production, in turn, is linked to water use.

3.5 WATER AND FOOD SECURITY

Food security is the outcome of many interrelated factors, one of which being water, an essential resource for food production. According to Hubbart (1995) people's access to water in rural areas, and the price of water, affect their food security for the following reasons:

- Rural water costs tend to be high and unstable, whether in monetary terms or in the time and effort required by households to fetch water, thus influencing their real incomes.
- Rural clean water sources are often vulnerable to droughts and floods, leading to increased costs of obtaining clean water at times when food prices typically are also likely to be high.
- Water-related local diarrhoeal diseases reduce food absorption (see chapter 4).
- Access to water for livestock and crop irrigation is the gateway from poverty for many in rural regions.

The potential benefits of the rural water supply in the context of food security are given in figure 3.5.

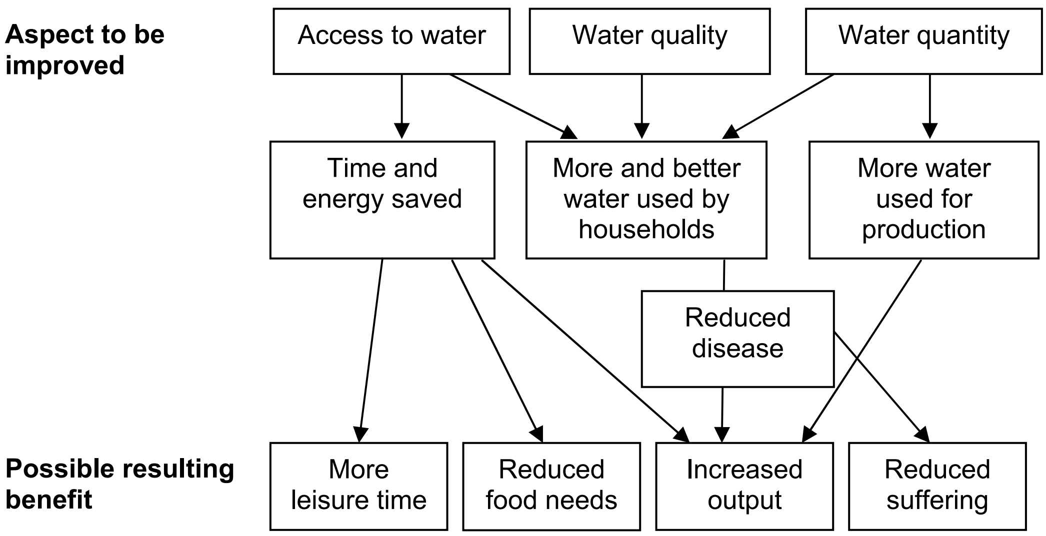


FIGURE 3.5: POTENTIAL BENEFITS OF A RURAL WATER SUPPLY
Source: Hubbard, 1995

3.5.1 WATER AND FOOD PRODUCTION

It is well documented that food production is by far the most water-intensive activity in society. Agriculture accounts for 70% of the worldwide human fresh water use (Gerbens-Leenes & Nonhebel, 2004) and this figure can be as high as 90% in developing countries (SIWI-IWMI, 2004). Whilst about 50 L of water per day per person is the recommended minimum for household use, 70 times as much (2500 L) is needed to meet the consumptive water use for producing a projected human diet consisting of 3000 kcal (12 600 kJ) per day for one person (SIWI IFPRI IUCN IWMI, 2005:7). Large volumes of water are transformed into vapour during production in the form of plant transpiration and evaporation from the fields, canals, reservoirs and high water tables (SIWI-IWMI, 2004). Water, however, is a limited resource, and consequently could become a limiting factor in increasing food production. This is of particular relevance to some of the drought-vulnerable, rural regions with both a high prevalence of under-nutrition and a rapid population growth. Rosegrant *et al.* (2002) provided a global model of supply and demand for food and water and showed that, if current water policies continue, farmers will find it difficult to meet the world's food demands. They thus project that the global yield growth rate for all cereals will decline from 1.5% from 1982 to 1995 to 1.0% per year from 1995 to 2025.

Using achievement of the MDG (see chapter 1) as global challenge and commitment, the Swedish government, the Stockholm International Water Institute (SIWI) and the International Water Management Institute (IWMI) of Colombo in 2004 (during the 12th meeting of the Commission on Sustainable Development) released the results of a study titled "Water – more nutrition per drop". In that study it is argued that a fundamental reconsideration of the role of water in sustainable food production and food consumption patterns is essential in order to produce more food with less water (SIWI-IWMI, 2004). During the 13th meeting of the Commission this message was reaffirmed with the publication: "Let it Reign: The new water paradigm for global food security" (SIWI IFPRI IUCN IWMI, 2005:7).

3.5.1.1 Nutritional water productivity

In the context of crop production “water use”, “water requirement”, “water productivity” or “water use efficiency” are all concepts that refer to the ratio of crop yield to water consumed (production per unit of water depleted) expressed as kg of crop per m^3 of water (Renault and Wallender, 2000). For a particular crop this form of productivity depends on many factors, including climate, geographical location and duration of the cropping season (SIWI-IWMI, 2004). For this reason Gerbens-Leenes and Nonhebel (2004) differentiate between a crop-specific and a site-specific water flow. The latter refers to the local hydrological system and the factors mentioned above. It follows that any information on “total” water use of a crop obtained at a specific site cannot necessarily be used for other locations. Table 3.4, setting out water requirements to produce a kilogram of various food items, should thus be interpreted with this in mind. Nevertheless, regardless of the geographical site, the table shows that much more water is needed to produce animal-based foodstuffs compared to plant-based commodities.

TABLE 3.4: WATER REQUIREMENTS (m^3/kg) OF VARIOUS FOODS

Food	Water requirement: SIWI-IWMI (2004) [a]	Water requirement: Renault & Wallender (2000) [b]	**Comments** (SIWI-IWMI, 2004)
Beef	15 or more (grain fed)	13.5	Demand increased by about 5% annually during last 20y in LDCs, although not in all countries.
Lamb	10	NA	
Poultry	6	-	Its share in meat consumption has more than doubled over the last 3 decades
Poultry and pork	NA	4.3	
Cereals	0.4-3	0.7-1.4	Current world output of 1.7 billion tonnes expected to increase to 2.6-2.8 billion tonnes in 2025
Fruits	NA	0.45	
Citrus fruits	1	NA	
Palm oil	2	NA	Growth by 3% expected
Fat products	NA	11-18	
Pulses, roots and tubers	11	NA	
Nuts	NA	2.5-4.8	
Milk	NA	0.8	
Vegetables	NA	0.15	

[a] : Based on several international sources
[b] : Reference to California (optimal conditions)
NA: Not available

An emerging concept, which takes water productivity a step closer to human nutrition, is “nutritional water productivity” (NWP). It quantifies nutrition per volume water expressed as nutritional units per m^3. The nutritional units refer to energy (kJ) or nutrients. The formula used for calculation is:

$$\mathbf{NWP} = \frac{\mathbf{Y_a}}{\mathbf{ET_a}}\ \mathbf{NP}$$

Y_a is actual harvested yield (kg/ha)
Et_a is actual evapotranspiration (m^3/ha)
NP is nutrition content per kg product (nutrition unit /kg) (Renault & Wallender, 2000).

An indication of the NWP (in terms of energy and protein) of various foods in the Californian environment is given in table 3.5. In this study FAO balance sheets were used to calculate the nutritional content of the individual foods. Again, whilst the absolute values may not be applicable to South Africa, the trends between foods are relevant. The table shows that energy productivity for animal foods is low and conversely it is high for cereals, ranging from 428 kJ/m^2 for beef to 5 626 kJ/m^2 for potatoes. This high energy productivity of maize and potatoes can be taken even further: if, for example, a human energy requirement of 2 700 kcal/day (11 340 kJ/day) is assumed, then these two commodities could cover the daily energy needs with much less than 1 m^3 of water per capita daily (Renault & Wallender, 2000).

TABLE 3.5: NUTRITIONAL WATER PRODUCTIVITY OF VARIOUS FOODS

	Nutritional water productivity		
	Energy		Protein
	kcal/m^3	kJ/m^3 *	g /m^3
Cereals			
Wheat	2 279	9 572	74
Rice	1 989	8 354	49
Maize	3 856	16 195	77
Legumes, nuts and oils			
Pulses (beans)	1 188	4 990	76
Treenuts	521	2 188	14
Groundnuts	2 382	10 004	111
Soybean oil	547	2 297	0
Cotton seed oil	721	3 028	0
Vegetables, roots and tubers			
Tomatoes	1 416	5 947	65
Onions	2 259	9 479	85
Sugar beets	2 520	10 584	0
Potatoes	5 626	23 629	150
Fruit			
Oranges	663	2 785	13
Lemons	504	2 117	0
Grapefruit	553	2 323	0
Bananas	432	1 814	11
Apples	1 140	4 788	6
Pineapples	1 136	4 771	0
Dates	731	3 070	0
Grapes	1 356	5 695	14
Animal products			
Beef	102	428	10
Pork meat	408	1 714	21
Poultry meat	330	1 386	33
Eggs	519	2 180	41
Milk	659	2 768	40
Butter	404	1 697	1

kcal x 4.2 (rounded to whole figures);
Source: selected information from Renault and Wallender (2000)

Protein productivity of animal-based foods, which are generally considered important sources of protein, ranges from 10 g/m^3 of water for beef (i.e. about 13% of a hypothetical protein requirement of 75 g per day) to about 40 g/m^3 for eggs and milk (i.e. about 53% of a hypothetical daily requirement of 75 g). Again potatoes perform very well: the protein productivity is 150 g/m^3 (i.e. it would supply 75 g of protein with only 0.5 m^3 of water) (Renault & Wallender, 2000).

Diets are, however, not composed of individual foods. Using the NWP figures from table 3.5, Renault and Wallender (2000) calculated the theoretical water requirements of the current American diet and the increase in water productivity that could be achieved if the current American diet ("Diet 0" in table 3.6) would progressively be adjusted to contain more plant-based commodities (table 3.6).

TABLE 3.6: PER CAPITA PRODUCTIVITY OF WATER FOR DIFFERENT TYPES OF DIET

Type of diet	Water requirements m^3/day/person (California)	% Increase in water productivity from current American diet ("Diet 0" *)
Diet 0 *	5.40	0
All animal products of Diet 0 reduced by 25% and replaced by plant-based products	4.60	17
50% of beef in Diet 0 replaced by poultry	4.80	11
50% of beef and pork in Diet 0 replaced by potatoes and groundnuts	4.40	22
50% reduction of all animal products and replacement with vegetal products. Oils reduced to match energy intake to target	3.40	59
Vegetarian: no meat; eggs and butter as in Diet 0; milk reduced to 70% of Diet 0. Increase in plant-based products	2.60	103
Vegan: potatoes, groundnuts, onions and carrots	1.00	440

*USA Diet as consumed in 1995: Composition per annum: 178kg vegetables, 121kg fruits, 113kg cereals, 67kg sugar products, 277kg milk eggs and butter, 29kg oil, 117kg meat
Source: based on Renault and Wallender, 2000

In a similar vein the SIWI-IWMI study claims that using currently prevailing (global) production methods for land and water management practices, today's diets, on average, represent a depleting water use per capita of 1200 m^3 ^{p}er person per year, with large variations between different regions. These vary from 600 m^3 per year in the poorest regions to 1 800 m^3 per year in regions with the highest meat-based intakes. This research group states that for an acceptable nutritional intake including 80% plant and 20% animal sources, about 1 300 m^3 water per person per year would be needed, whereas a purely vegetarian diet requires about half as much (SIWI-IWMI, 2004:23).

Individual and societal food choices and preferences are influenced by many factors at a particular point in time (Cox & Anderson, 2004) and they also change over time – as part of global evolutions or revolutions, or based on personal decisions - for individuals, specific cultural groups and mankind as a whole (Fernandez-Armesto, 2001; Kuhnlein & Receveur, 1996 – see also figure 3.6 "Traditional food systems"). Ultimately the food choices of individuals and populations result in consumer demand in the market place, which, in turn, is the major driver of food production. In this way food consumption trends will ultimately have implications on water and other environmental factors - something that consumers are largely ignorant or misinformed about. Raising water and environmental literacy could contribute to a change in food choices (SIWI-IWMI, 2004; ADA, 2001).

A consumption-based indicator of a nation's water needs is the so-called "water foot print". It is defined as the total volume of fresh water, both green (i.e. moisture in the soil) and blue (i.e. water-associated irrigation from aquifers, rivers and lakes), that is used to produce the goods and services consumed by the people of the nation, i.e. both food and other goods and services (SIWI IFPRI IUCN IWMI, 2005:21). Behind any food basket (which reflects a consumer's food choice) there is a "water foot print", which, in general, increases in line with the amount of food consumed and, even more pronounced, with the type and composition of the diet.

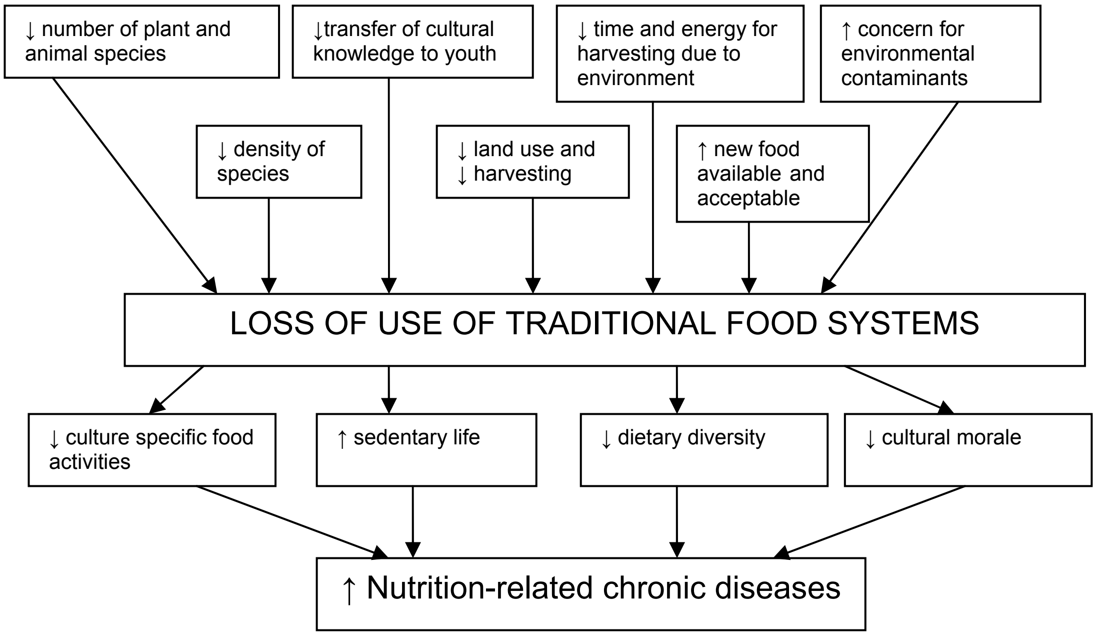


FIGURE 3.6: FACTORS INFLUENCING LOSS OF TRADITIONAL FOOD SYSTEMS, AND SOME HEALTH CONSEQUENCES
Source: Kuhnlein & Receveur, 1996

Feeding more people with the same amount of water thus appears to be a very important consideration for the promotion of food security. Apart from the consumer-demand (dietary preference/consumption) perspective as discussed above, this could also be achieved in numerous other ways, including increased production through cultivation of indigenous plants known to be water-productive. In South Africa there has been an increased awareness of the potential of indigenous plants as food (e.g. the book by Van Wyk and Gericke (2000) "People's plants", which covers many cereals, seeds and nuts, fruits and berries, vegetables, and roots, bulbs and tubers) and the indigenous knowledge related to plants and water (e.g. the *Citrillus lanatus* (Tsamma) fruits, which act as important source of water in the Kalahari during the nine dry months of the year).

The harvesting of wild resources has been identified as the "least visible and most underestimated economic activity" in rural communities, contributing to the direct-use values of sustainable livelihoods (Turner, 2004:48-9). It must, however, be remembered that in many societies there has been a loss of traditional food systems, which has been linked to an increased prevalence of nutrition-related diseases amongst some indigenous peoples (Kuhnlein & Receveur, 1996). This is illustrated in figure 3.6.

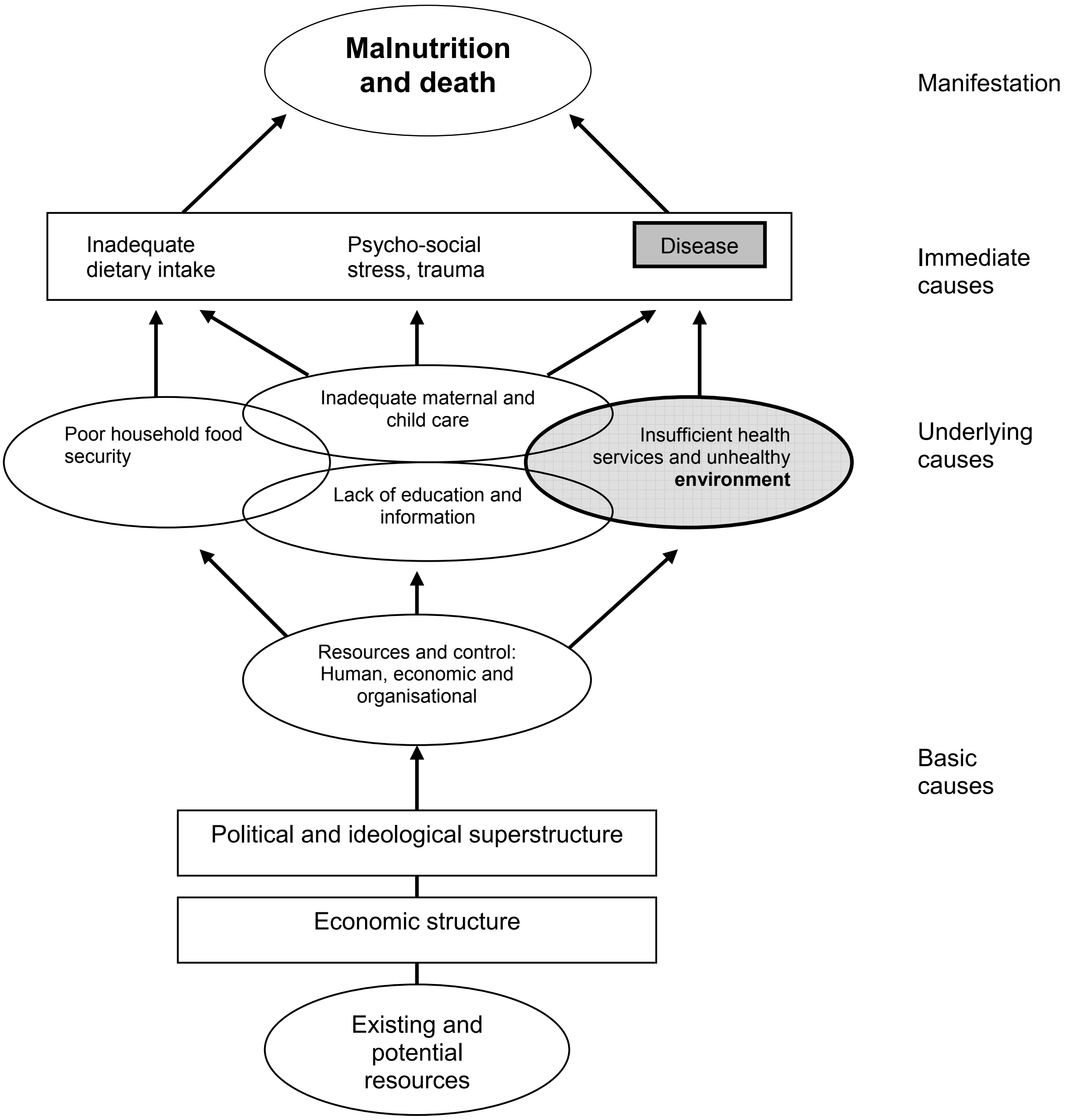
Other methods of increasing production without using more water include promoting crops that are well adapted to harsh climatic and growth conditions (e.g. cowpeas [*Vigna unguiculata*], bambara groundnut [*Vigna subterranea*] or marog [*Amaranthus* spp]), breeding drought-tolerant crops (e.g. GM crops for enhanced micronutrient content) (Welch & Graham, 2002), changing agronomic and field practices (e.g. soil tillage, precision land levelling, alternate wetting and drying, mulching and fertiliser practices), applying low-cost supplementary irrigation technologies for rain-fed areas (e.g. bucket and drip sets; drum and drip micro-irrigation; drip and sprinkler irrigation), improving irrigation management practices (e.g. to improve reliability and timing of water provision), reutilising water, introducing innovative water pricing systems and incentives, etc. (Khosa, 2003 Kundhlande *et al.*, 2004; SIWI-IWMI, 2004:25-28; SIWI IFPRI IUCN IWMI, 2005:14; Spreeth *et al.*, 2004).

3.6 CONCLUDING REMARKS

A three-pronged approach is needed to link nutrition and agriculture successfully. The intervention must have a well-designed agricultural component as well as a well-designed nutritional component, and these two components should be mutually reinforcing (Bonnard 1999). Using a gender-sensitive approach can strengthen the link between nutrition and agriculture. Agriculture forms the basis of food security. This of course helps to eliminate food insecurity, one of the underlying causes of malnutrition. To achieve all the agricultural and nutritional objectives, water, one of the essential resources needed for food production, plays a critical role.

CHAPTER 4

WATER IN HUMAN HEALTH AND NUTRITION



INTRODUCTION

Apart from household food insecurity as discussed in the previous chapter, not having access to a physically healthy as well as a socially caring environment can lead to malnutrition. These two aspects, health and care, are the distinguishing features of *nutrition security* (as opposed to food security) as underlying determinants of good nutrition. This chapter focuses on the role of water as part of the physical environment in the causation of disease and malnutrition (figure 1.1) with special emphasis on South Africa and the major nutritional issues facing the country, as discussed in chapter 2.

Water is part of the resources mentioned as the basic causes of malnutrition in figure 1.1. From a global perspective, the impact of the world's water resources on human health is typically described in terms of water scarcity, water quality and water-related disasters (Kistemann, 2004:55). The precipitation that falls on land surfaces is the main source of water needed for human use, agriculture and food production, and for industrial waste disposal. Current calculations estimate that 54% of the accessible runoff water is appropriated by humans. As *per capita* use of water increases due to lifestyle changes (leisure and domestic practices as well as eating habits) the proportion of appropriated water rises, which means that global water shortages are likely to increase (Kistemann, 2004:55). Water scarcity and water quality as reflected by chemical and microbial risks on household and individual level are discussed in more detail the rest of this chapter. Even though floods worldwide constitute the most frequently reported disaster, and droughts claim the greatest number of victims (Kistemann, 2004:59), these water-related disasters and their effects on human health are not covered by this review.

Within the physical meso-environment (part of the underlying causes of malnutrition in figure 1.1) the water supply of a household could play a critical role. Rosen and Vincent (1999:2) developed an outline of the paths that lead from a household's water supply to the productivity of that household (figure 4.1). They base their analysis on the rural sub-Saharan context in which two categories of cost are distinguished: costs to households due to water-related diseases, and costs linked to water collection. From figure 4.1 the health implications of an inadequate water supply become clearer, but at the same time the relation to aspects such as productivity is emphasised.

Using figure 4.1 as basis, Rosen and Vincent (1999:32) argued that the nutritional and energy costs of a poor water supply in the sub-Saharan context are at least threefold:

First, there is additional energy expenditure if water is collected from a distant source. Three studies were reviewed that estimated the toll of carrying water on rural African women's energy balance. In these studies the average daily additional energy expended to carry water ranged from 217 kcal (910 kJ) to 240 kcal (1 010 kJ). This represented about 8-10% of the carrier's daily energy intake. As such it could affect nutritional status and could also be converted to a monetary value, affecting food security (Rosen & Vincent, 1999:53-55, 73).

A second potential link between water supply and nutrition is through the availability of water for cooking food. Observations from Mozambique suggest that households with close access to water use more water for cooking than households whose water supply is distant. Rosen and Vincent (1999:32) were, however, unable to find estimates of the extent to which malnutrition in sub-Saharan Africa is exacerbated by inadequate water for cooking.

A third way in which a poor household water supply could affect nutrition is via the effect of diseases associated with water. This is reviewed in more depth in section 4.2.

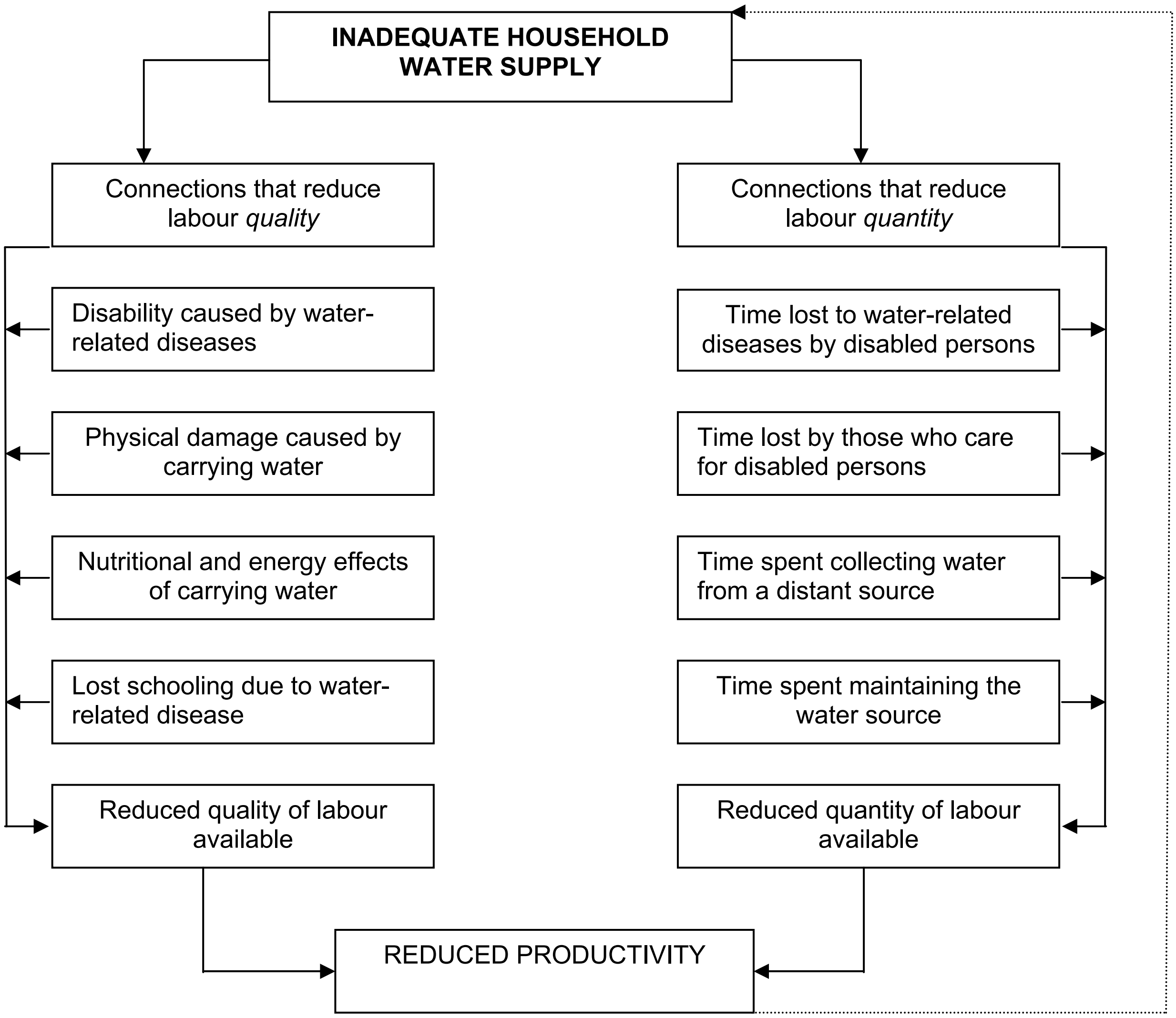


FIGURE 4.1: RELATIONSHIP BETWEEN HOUSEHOLD WATER SUPPLY AND PRODUCTIVITY

Source: Rosen & Vincent, 1999:2

The importance of water for optimal human nutrition in South Africa was publicly acknowledged when the Department of Health officially adopted the Food Based Dietary Guidelines (FBDG). One of the eleven guidelines specifically refers to water and spells out: "Drink lots of clean, safe water" (Vorster *et al.*, 2001), which implies that from a holistic, public-health perspective good nutrition in South Africa is intrinsically linked to water. Within the guideline there is a clear distinction between the quantitative ("*lots*") and the qualitative ("*clean and safe*") component of water intake. In the following sections of this chapter we will discuss these two aspects – human water requirements and water quality for good health and nutrition.

4.1 WATER REQUIREMENTS AND INTAKES (QUANTITY NEEDED)

For an individual water is a core but often overlooked nutrient which is essential for survival and good health. It has many functions in the human body, including

- acting as a solvent in which inorganic salts, organic compounds and dissolved gases interact
- participating in metabolic reactions
- maintaining the structure of macromolecules

- stabilising cell membranes
- thermoregulation
- transporting nutrients
- maintaining hemostasis and body volume / weight (Bourne & Seager, 2001; Kleiner, 1999; Mahan & Escott Stump, 2004; Sawka *et al.*, 2005;)

As is the case for some other nutrients, both under-supply (resulting in dehydration) and over-supply (over-hydration or water intoxication) of water should be avoided. In this context the total percentage of body weight contributed by water must be kept in mind (which varies with age, gender and percentage body fat). Also, the distribution of total body water into intra- and extra-cellular water (including the intra-vascular, i.e. plasma and blood, and the intercellular, i.e. interstitial, water) must be considered when the optimal hydration status of an individual is evaluated (Mahan & Escott-Stump, 2004:165).

In healthy people water intake is mainly controlled by the thirst control centres in the ventromedial and anterior hypothalamus in close relationship with anti-diuretic hormone (Mahan & Escott-Stump, 2004:165). Theoretically plasma or serum osmolality acts as primary indicator of hydration status (DRI, 2004:73), and an osmolality of <285 mOsm/L is often taken as indicative of water excess, and an osmolality of >295 mOsm/L as a water deficit (Mahan & Escott-Stump, 2004:168). In practice, however, Armstrong (2005) contends that "there is currently no single, infallible method for assessing hydration status of a person". Nevertheless the importance of "good hydration" for day-to-day health (Ritz & Berrut, 2005), for work and exercise/sporting performance (Shirreffs, 2005; von Duvillard *et al.*, 2004) and for prevention of chronic (non-communicable) diseases (Manz & Wentz, 2005; Bourne & Seager, 2001; Kleiner, 1999) has been emphasised.

Normal water needs range widely due to many factors, some of which are inter- and intra-individual, while others are related to environmental conditions, which can cause water loss. The result is that there is currently no RDA for water, because the scientific evidence is inadequate to set an Estimated Average Requirement (EAR). Instead, the Institute of Medicine of the National Academy of Sciences' Dietary Reference Intake (DRI) Panel has officially established Adequate Intakes (AI), which are an approximation of average intakes of groups of healthy people, and should meet the water needs of the majority of healthy adults (DRI, 2004). These AIs have been set as 3.7 L and 2.7 L/day for men and women older than 19 y respectively. This refers to total water intake of an individual, including about 80% from fluids and 20% from foods. The fluids consumed do not have to be only water; individuals can obtain their fluids from a variety of beverages and foods (DRI, 2004).

Water from the cellular oxidation of food plays an additional role when the input side of a person's water balance (homeostasis) is investigated. On the other hand, when quantifying water output, water in urine, faeces, perspiration and insensible losses in the skin and respiratory tract must be accounted for (Mahan & Escott-Stump, 2004). Water balance is eventually closely associated with electrolyte and acid-base balance, and is usually described in relation to these aspects.

Guidelines for the water provision for a *population* (based on a 70 kg and a 58 kg adult reference male and female respectively, under "average" conditions) have been included in the WHO report "Domestic water quantity, service level and health", and amount to 2.5 L/day for males and 2.2 L/day for females (WHO, 2005:33).

Water requirements of individuals in different stages and circumstances in the healthy life cycle (e.g. childhood, pregnancy and lactation as well for the elderly, in sports, extreme weather conditions or the military) and in disease (e.g. during diseases affecting hydration and in critical care such as during enteral feeding) call for special attention and are beyond the scope of this report.

4.1.1 Water / fluid consumption of (South) Africans

Rosen and Vincent (1999:10-14,70) reviewed studies on household water use in rural areas of sub-Saharan Africa. They identified the four “best available studies” among a list of about 15 publications, and concluded that a rough average use of water in rural areas was around 10 L per person per day, with huge variations between countries, villages and households. This value (10 L/person/day) is the same as that quoted by Kistemann (2004:56) as reflecting the amount of water used by “the average person in the developing world”. In general this is far below what is commonly considered enough to maintain the level of personal and domestic hygiene needed for good health. These figures do, however, not refer to water intakes of individuals and can thus not be interpreted in that context.

Very few publications deal specifically with water or fluid intakes in South Africa. In the latter part of the 1980s the mean total intake of tap water (based on 24-h recalls) for the white population of Cape Town aged 1 y and over (N=1680) was reported to be 2.19 L/day, whilst that for the coloured population (N=1088) was 1.26 L/day. Intakes of black inhabitants aged 5 y and older in the same population but from another study using the same methodology (N=1415) were 1.4 L/day (Bourne & Seager, 2001; Bourne *et al.*, 1987; 1992).

These reported intakes of tap water can also not be interpreted relative to the AI, as the AI’s for water relate to total intake from all beverages and food (see 4.1). Furthermore, tap water is not the only source of water for South Africans as indicated by the national census (see table 4.1). In addition, Cape Town cannot be considered as being representative of the South African population. In fact, for the country as a whole, the water supply varies hugely by province and by population group of the head of the household: only 18% of households in the Northern Province have taps inside the dwelling, compared with 76% in the Western Cape (where Cape Town is located). Equally, 27.3% of Africans have a taps in their dwelling, compared to 97.6% of Indians. Table 4.1 shows that, overall, fewer than half of the households in the country have a tap inside the dwelling. It follows that there appears to be no nationally representative data on water/fluid intakes of South Africans.

TABLE 4.1: MAIN WATER SOURCE FOR SOUTH AFRICAN HOUSEHOLDS IN OCTOBER 1996 (excluding unspecified, institutions and hostels)

Water source	Percentage of households
Tap inside	44.7
Public tap	19.8
Tap on site	16.7
Dam/river/stream	12.5
Borehole/rainwater	5.0
Water carrier	1.2

Source: Statistics South Africa, October 1996 (Statistics South Africa, 1999)

4.2 WATER QUALITY (SAFETY AND CLEANLINESS)

Safe and clean water is an important element of a health-promoting environment. Lack of such an environment forms part of the underlying causes of malnutrition in the UNICEF conceptual framework (see figure 1.1). Provision of safe water and sanitation is also one of the eight core elements of PHC as stipulated in the "health for all" paradigm which was officially adopted by the South African Department of Health. Finally, safety and cleanliness represent the second aspect of the South African FBDG relating to water.

4.2.1 Diseases associated with water

Unsafe and dirty water can be associated with numerous diseases. Substances in water that can be related to health and well-being can be grouped in numerous ways, but in the WHO "Guidelines for drinking water quality standards in developing countries" (Solsona, 2002:21) the following classification (WHO-GL) of substances has been adopted:

- Microbiological
- Chemical (health-related)
    - Inorganic
    - Organic (other than pesticides)
    - Pesticides
    - Disinfectants (e.g. chlorination) and disinfectant by-products
- Radiological
- Aesthetic

Of the above microbiological substances and inorganic (nutritive) chemicals are discussed in more detail because their relationship to nutrition is relatively well documented and/or their impact is of public health concern. The potential effect of the other substances on nutritional status is, however, acknowledged.

The *microbiological* quality of drinking water concerns consumers, water suppliers, regulators and public health authorities. David Bradley has developed a classification of water-related diseases with a microbiological base. This classification is widely used, for example by the United Nations Environmental Programme (Tolba & El-Kholy, 1992) and by Harvard University (Rosen & Vincent, 1999:15-16) (table 4.2). Strictly speaking, not all of these are linked to drinking water quality (e.g. the "water-washed" diseases), but for the sake of comprehensiveness the whole classification is given here. Equally the classification "faecal-oral diseases" is often used to replace the water-borne category because this is the most common pathway of transmission, even though it would include water-borne and water-washed conditions (Rosen & Vincent, 1999). Using the word "faecal-oral" implies the link between these diseases and matters of sanitation and hygiene, which tend to be closely related to water.

A significant proportion of the global burden of disease is linked to water-related illnesses. At any given time about half of the world's hospital beds are occupied by patients suffering from waterborne disease (Kistemann, 2004:59), and this has significant financial implications for the health care system. The mean total inpatient cost of treating diarrhoea caused by rotavirus in the Dr George Mukhari Hospital in South Africa has recently been estimated at about R8 000 per person (MacIntyre, 2006).

TABLE 4.2: INFECTIOUS DISEASES ASSOCIATED WITH WATER

Disease group	Description	Examples
Water-borne	Water acts as a passive vehicle for infective agent, thus transmission is via consumption of contaminated water	Bacterial: *Salmonella typhoid, Enterobacteria, *Cholera Viral: Hepatitis A, Rotavirus Parasitic: Amoebiasis, giardiasis, intestinal protozoa, ascariasis, hookworm
Water-washed	Infections that decrease as a result of increasing volume of available water; thus the disease is a result of insufficient quantities of water for personal or domestic hygiene	Enteric: Some diarrhoeas and gastroenteritis Skin: Scabies Louse-borne: Typhus Eye & ear: Otitis, conjunctivitis, trachoma
Water-based	A necessary part of the life cycle of the infective agent takes place in an aquatic organism; thus infection is transmitted through repeated contact with or ingestion of contaminated water e.g. bathing or washing clothes	Crustaceans: *Guinea worm disease (dracunculiasis) Fish: Diphyllobothriasis Shellfish: Flukes, *schistosomiasis (bilharzias)
Water-related (vector-borne)	Infections spread by insects that breed in water or bite near it	Mosquitoes: *Malaria, yellow fever, haemorrhagic fever Tsetse flies: Trypanosomiasis ("sleeping sickness") Blackflies: *Onchocerciasis ("river blindness")

* Common in sub-Saharan Africa (Rosen & Vincent, 1999)
Source: Tolba & El-Kholy, 1992:549; Rosen & Vincent, 1999:15-16; Kistemann, 2004:58-59

Based on information contained in table 4.2, water, sanitation and hygiene as a composite risk factor thus includes the following transmission pathways (Kistemann, 2004:60):
Transmission through:

- ingestion of contaminated water (e.g. pathogens or chemicals)
- lack of water linked to inadequate hygiene (e.g. scabies or trachoma)
- poor personal, domestic or agricultural hygiene (e.g. use of contaminated water for irrigation or cleaning)
- contact with contaminated water (e.g. *Schistosoma* spp)
- vectors proliferating in water (e.g. malaria)
- contaminated aerosols from poorly managed water systems (e.g. legionellosis)

4.2.1.1 Diarrhoea

Of the diseases listed in table 4.2, those that precipitate with diarrhoea remain among the most important causes of global childhood mortality and morbidity. Patho-physiologically, diarrhoea results when excess water and electrolytes are actively transported into the lumen of the gut (secretory diarrhoea) or when water is retained in the lumen by osmotically active agents (osmotic diarrhoea). Finally, gastrointestinal motility (i.e. movement within the gut) affects transit time, thereby contributing to diarrhoea (Manas *et al.*, 2003:198). Micro-organisms associated with water (see table 4.2) can be the underlying cause of increased secretion or osmotic pressure (e.g. by means of fermentation), resulting in diarrhoea.

Diarrhoeal disease alone is estimated to cause 2.2 million of the 3.4 million global water-related deaths per year (WHO/OECD, 2003), with huge differences between developing and developed countries (Thapar & Sanderson, 2004). Exact prevalence figures remain elusive because a significant proportion of water-related illnesses are likely to go undetected by general surveillance systems. The major reason for this is that the gastrointestinal symptoms are usually mild and self-limiting and are consequently not reported. Even among those events that are reported, few of the stools will be microbiologically analysed so that a causative micro-organism can be recorded.

In South Africa the incidence of diarrhoea is used as one of the indicators of the health status of the nation's children and for identification of potential environmental hazards. The *"diarrhoea incidence <5 per 1000"* is defined in the South African Health Review as the number of children <5 y with diarrhoea per 1000 children <5 y in the target population. In that report diarrhoea indicates three or more watery stools in 24 hours, but any episode diagnosed and/or treated as diarrhoea after an interview with the adult accompanying the child should also be counted (SAHR, 2002). The national prevalence figure for diarrhoea given in that report is 174.3. This refers to the number of children seeking treatment for diarrhoea from PHC facilities, and reflects about half the number of cases expected based on the number of cases reported in the South African DHS in 1998 to have experienced diarrhoea in the two weeks prior to the survey (SAHR, 2002).

In line with global trends inequities in the incidence of diarrhoea in South Africa are evident from official statistics: The figures reported in the SAHR for the year 2000 range from 67.7 for Gauteng, to 292.2 for KwaZulu-Natal. In table 4.3 the socio-economic living conditions relating to water and sanitation are given per province and population group, confirming the above-mentioned diarrhoea-related inequities.

TABLE 4.3: SELECTED HOUSEHOLD LIVING CONDITIONS IN SOUTH AFRICA

		Refuse removal %	Access to piped water* %	Piped water in home %	No toilet facility %
Province	Eastern Cape	36.6	62.4	17.8	30.8
	Free State	58.6	95.7	22.8	9.6
	Gauteng	84.2	97.5	47.2	3.6
	KwaZulu-Natal	49.2	73.2	29.6	16.2
	Limpopo	14.2	78.0	9.4	23.3
	Mpumalanga	38.7	86.7	21.4	10.3
	Northern Cape	68.7	96.6	39.7	11.2
	North-West	37.0	86.2	18.3	9.7
	Western Cape	87.8	98.3	67.5	7.7
Population group	African	45.3	80.3	17.9	16.9
	Coloured	84.1	97.6	66.8	6.0
	Indian / Asian	96.8	99.2	87.5	0.8
	White	90.8	99.3	87.2	0.7
South Africa		55.4	84.5	32.3	13.6

Includes households with piped water in dwelling, piped water inside yard or piped water on a community stand (< 200m away or further).
Source: SAHR, 2005; http://www.hst.org.za/uploads/files/sahr05_chapter17.pdf: accessed 31 August 2006

The top ten causes of death in children <5 y in South Africa in 2000 are given in table 4.4. The table shows that diarrhoea is in the 3rd position reflecting over 10% of deaths, and protein-energy malnutrition in 5th.

TABLE 4.4: CAUSES OF DEATH IN CHILDREN UNDER 5 Y, SOUTH AFRICA, 2000

Rank	Cause of death	Number of deaths	%
1	HIV / AIDS	42 749	40.3
2	Low birth weight	11 876	11.2
3	Diarrhoeal disease	10 786	10.2
4	Lower respiratory infections	6 110	5.8
5	Protein-energy malnutrition	4 564	4.3
6	Neonatal infections	2 920	2.8
7	Birth asphyxia and trauma	2 584	2.4
8	Congenital heart disease	1 238	1.2
9	Road traffic accidents	1 219	1.1
10	Bacterial infections	1 141	1.1

Source: SAHR 2003/4 http://www.hst.org.za/uploads/files/chap4_03.pdf: 54; accessed 31 August 2006

Malnutrition globally remains the major adverse prognostic indicator for diarrhoea-related mortality, emphasising the importance of nutrition in early management (Thapar & Sanderson, 2004) and, again, suggesting an interaction between nutrition and diarrhoea. Diarrhoea is often a manifestation of a number of infectious diseases, and the bi-directional interaction between nutrition, infection and immunity is well known and reflected in figure 4.3. Under-nutrition impairs immune defences and lowers resistance to invading pathogens. In turn, infection alters nutrient status and contributes to the undernourished state.

From the above discussion it is evident that ill-health, or more specifically the presence of (infective) diseases associated with water, features strongly as a mediating variable in the relationship between water and nutrition, thus resulting in what is sometimes called disease-related malnutrition (Stratton, 2003).

It is possible that interventions to improve sanitation and hygiene are more effective in reducing diarrhoea morbidity and mortality than interventions that improve water supplies as such. Rosen and Vincent (1999:39-43,72) investigated this but were unable to find any research from sub-Saharan Africa that separated these effects. Sanitation appears to be critical to specifically reduce faecal-oral diseases, but has little value in combating other conditions associated with water. Changes in z-scores of weight-for-height, height-for-age and weight-for-age suggest that provision of *optimal* (in contrast to intermediate or unimproved) services of *either* water *or* sanitation (whether separately or in tandem) generate health benefits in the form of improved growth and anthropometry of children in Africa (Rosen & Vincent,1999:39-43, 72). (See glossary and chapter 2 for explanation of nutrition terminology related to anthropometry and statistics.)

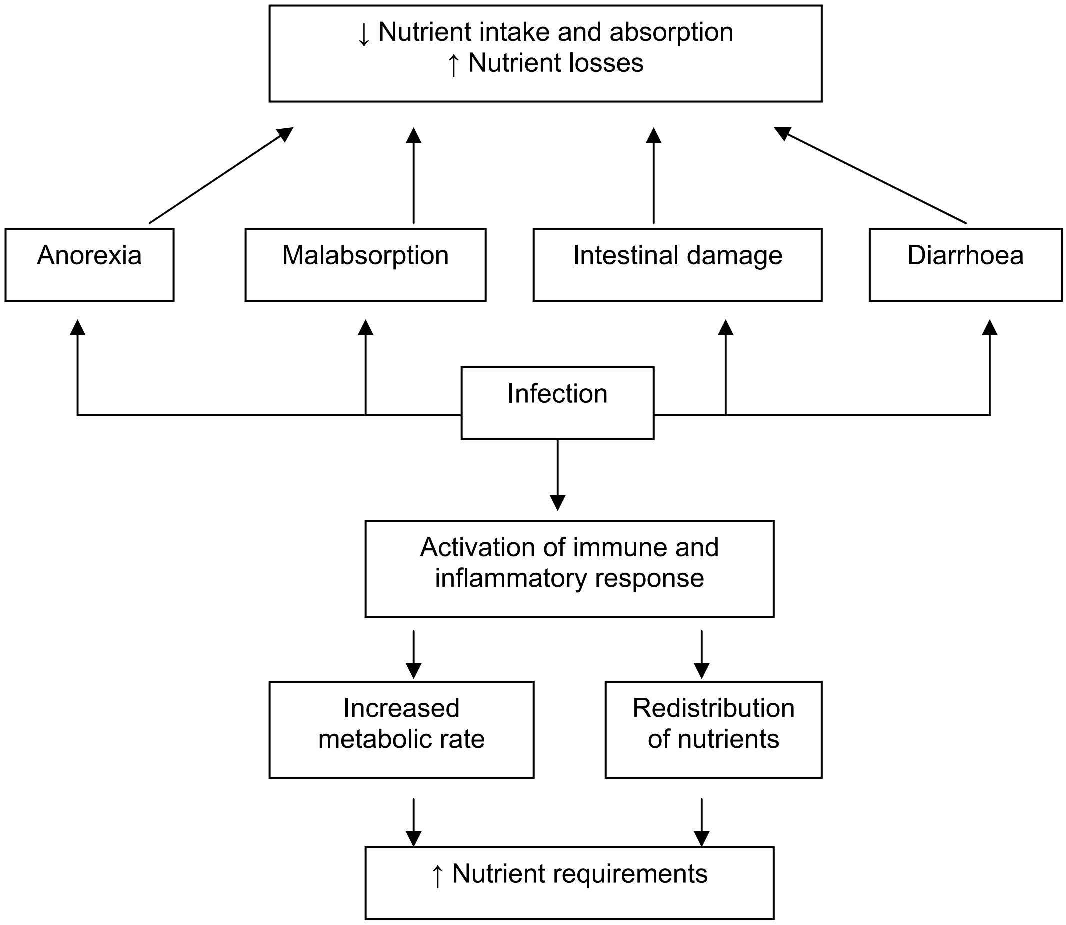


FIGURE 4.2: THE INTER-RELATIONSHIPS BETWEEN NUTRITION AND INFECTION
Source: Yaqoob & Calder, 2003: 292

4.2.1.2 Chronic diseases associated with water-related pathogens

In the 1990's some (preliminary) evidence became available that microbial infections associated with water-borne pathogens may also be linked to the development of chronic diseases long after the initial exposure, for example

- diabetes mellitus linked to the Coxackie B4 virus
- miocarditis linked to echovirus
- Guillian-Barrè syndrome linked to *Campylobacter* spp
- gastric cancers linked to *Helicobacter* sp
- reactive arthritis linked to *Klebsiella* sp (WHO/OECD, 2003:13)

We can thus conclude by saying that microbiological contamination of water plays a major role in the global burden of mainly infective diseases, and in particular those that present with diarrhoea, but may also in the longer term be associated with chronic diseases.

4.2.2 Water as vehicle of non-living nutrition-related substances

Whilst water is often thought of as being only "H_2O", it contains nutrition-related chemical substances that can either positively or negatively affect health. These substances may be naturally present or added intentionally or unintentionally, and they can be organic or inorganic, as indicated by the previously mentioned WHO-GL classification (see section 4.2.1).

The inorganics that have received most of the attention because of their potentially harmful effects include the heavy metals such as aluminium, arsenic, asbestos, barium, cadmium, chromium, lead, mercury and nitrate/nitrite. Pesticides (e.g. DDT, Chlorpyrifos and Pyriproxyfen) and disinfectants (e.g. bromate and trihalomethanes) are also among the chemicals that constitute waterborne hazards (Solsona, 2002; Olivares & Uauy, 2005;43; Department of Water Affairs and Forestry, 1996; Kistemann, 2004:58). They are not discussed in further detail in this report.

4.2.2.1 Drinking water as a source of nutrients

Water contains numerous inorganic nutrients. Amongst these, fluoride is the most important from a nutrition perspective, as water (and not food) is its major source.

4.2.2.1.1 Fluoride

Fluoride has both detrimental and beneficial effects on human health and is (perhaps for that reason) sometimes a controversial subject. It is a natural element found in varying concentrations in surface water, ground water and seawater. Drinking water and water-based (non-dairy) beverages provide the bulk of fluoride intake for most people, accounting for 66-80% of fluoride intake in US adults (Lennon *et al.*, 2005).

In a Position Statement, the American Dietetic Association reviewed the impact of fluoride on health and reaffirmed that "fluoride is an important element for all mineralised tissues in the body. Appropriate fluoride exposure and usage is beneficial to bone and tooth integrity and, as such, has an important, positive impact on health throughout life" (ADA Position, 2005). Community water fluoridation is the adjustment of fluoride in a water supply to an optimal concentration of 0.7–1.2 ppm (depending on the ambient air temperature). This recommended level of 1ppm fluoride is considered optimal and safe for prevention of caries (ADA Position, 2005).

On the other hand, however, excessive fluoride intakes prior to tooth eruption (i.e. during enamel development) cause dental fluorosis, a hypomineralisation, mottling and discolouration of tooth enamel. Skeletal fluorosis and fluoride toxicity can occur at very high intakes. These effects have been the reason why some consumers have resisted universal fluoridation of public water supplies, complaining that they want to have a choice in the matter.

In South Africa the Department of Health has legislated regulations indicating that water service providers are obliged to fluoridate water to a concentration level of up to 0.7 mg F/L as of September 2003 (http://www.thewaterpage.com/randwater_fluoride.htm, accessed 30 January 2006). Nevertheless, the principles and practicalities of (universal) fluoridation are still being debated, and many matters in this regard remain unresolved.

Currently the South African Water Quality Guidelines state that in domestic water supplies as well as in industrial supplies used in the food and beverage industries the "fluoride concentration should not exceed approximately 0.7 mg/L" (Department of Water Affairs and Forestry, 1996:62). In the proposed regulations governing bottled waters, including natural mineral water (Department of Health, 2005:9), in South Africa, it is specified that bottled water containing more than 1mg/L fluoride shall have a prominent expression "contains fluoride". If it contains more than 2 mg/L the label must specify that the product is not suitable for infants and children < 7 yrs.

4.2.2.1.2 Other nutrients in water

Some minerals (apart from fluoride) which are essential for human health and which are found in drinking water at potentially significant levels include:

- calcium (bone health and possibly cardiovascular health)
- magnesium (bone and cardiovascular health)
- sodium (an extra-cellular electrolyte)
- copper (co-enzyme)
- selenium (antioxidant function and immunity) (WHO, 2005:5).

The relative contribution of water to total dietary intake of these nutrients is between 1 and 20%, with the largest proportion of intake from drinking water relative to that provided by food being from calcium and magnesium (Olivares & Uauy, 2005).

Many epidemiological studies in numerous countries have found an inverse (protective) association between cardiovascular disease mortality and increased water hardness (measured by calcium carbonate or another hardness parameter and/or calcium and magnesium content in water). These studies have been reviewed e.g. Klevay and Combs (2005), Calderon (2005) and Monarca and co-workers (2005).

In South Africa magnesium levels in the drinking water of twelve districts and deaths due to ischemic heart disease were assessed in the 1980s, and a significant negative correlation was found between these two variables in white, but not black, residents. Equally, in another South African study (by the same authors) an increased incidence of sudden death related to ischemic heart disease in some geographical areas where the soil and drinking water lacked magnesium was reported (Leary 1986 cited by Ong, 2005:63).

Other diseases that have been studied in relation to drinking water hardness and/or calcium/magnesium include renal stone formation, neural tube defects, cognitive impairment, diabetes, etc. (WHO, 2005:7).

Total hardness, according to the South African water quality guidelines, should be "limited to between 50 – 100 mg/L as $CaCo_3$, where possible" (Department of Water Affairs and Forestry, 1996:157).

Given the high prevalence of IDD worldwide, iodination of drinking water, using different kinds of iodinators, has been successfully implemented in some parts of the world. In China iodization of irrigation water has increased the iodine status of women and reduced neonatal and infant mortality (West *et al.*, 2004:224). In South Africa it was decided not use water as vehicle for iodine, and compulsory iodization of table salt is the main strategy to combat IDD.

4.3 REGULATIONS FOR TREATED AND BOTTLED WATER

The WHO has recognised that worldwide a variety of treatment processes aimed at improving the safety and/or aesthetic quality of drinking water are applied, ranging from desalination, remineralisation and filtration to disinfection. The potential health consequences of long-term consumption of such water (i.e. demineralised, remineralised or water of altered mineral content) have thus been reviewed and published (WHO, 2005).

In general the WHO "Guidelines for drinking water quality" (Sobsey & Bartram, 2003), including those specifically for developing countries (Solsona, 2002) are internationally used as basis for judging water quality. In South Africa the "South African water quality guidelines, Volume 1: Domestic use" and the "Specification: Drinking water (SABS 241 of 2001)" of the South African Bureau of Standards also serve that purpose. In terms of the former, a joint, follow-up publication by the Departments of Water Affairs and Forestry, Health and the WRC sub-divides domestic water use into drinking water, food preparation, bathing and laundry (each with a health and an aesthetic element). A colour coding (ranging from blue, green, yellow, red to purple to indicate best to worst case scenarios) is applied to each sub-division to describe “fitness for use”. Below is a summary of the coding and an explanation of “drinking water health effects” of each class.

TABLE 4.5: SOUTH AFRICAN COLOUR CODING OF DRINKING WATER QUALITY

Class	Quality description	Drinking water health effects
Blue	Ideal	No health effects; suitable for many generations
Green	Good	Suitable for lifetime use; rare instances of sub-clinical effects
Yellow	Marginal	May be used without health effects by the majority of individuals of all ages, but may cause effects in some individuals in sensitive groups. Some effects possible after lifetime use
Red	Poor	Poses a risk of chronic health effects, especially in babies, children and the elderly
Purple	Unacceptable	Severe acute health effects, even with short-term use

Source: WRC “Quality of domestic water supplies”, 1998:22

Some consumers try to avoid the perceived (or real) risks from community drinking water supplies by consuming bottled water. This has become an international trend (e.g. the USA, see ADA [2005]) and South Africans have also joined in. Bottled water in South Africa is regulated by the “Regulations governing bottled waters including natural mineral water” of the Foodstuffs, Cosmetics and Disinfectants Act 54 of 1972 (No.R.718, 28 July 2006). This includes “natural mineral waters”, “waters defined by origin” and “prepared waters”, each with an explicit definition and labelling requirements. The maximum levels for elements that may be present in the bottled water are also specified.

4.4 CONCLUDING REMARKS

A previous Director-General of the WHO, Halfdan Mahler, once stated that the number of water taps per 1000 of the population is an infinitely more meaningful health indicator than the number of hospital beds per 1 000 of the population (cited in Kistemann, 2004:61). The evidence presented in this chapter showed that poor health is clearly related to secondary malnutrition in South Africa. It follows that to prevent malnutrition in South Africa, water will have to be a key focal point.

CHAPTER 5

SUMMARY AND FUTURE PERSPECTIVE

Nutrition is a basic and key factor for development if measured in terms of the MDG (SCN, 2004). In general it seems possible that South Africa will achieve the MDG. Nevertheless, whilst no official trend data are available for South Africa in terms of progress on non-income poverty, i.e. the so-called “nutrition MDG - underweight”, reflected by target 2 of the MDG (World Bank, 2006 cited in SCN, 2006:11), this review on the nutritional status of South Africans shows high current and residual (i.e. after the proposed MDG halving) prevalence figures for child malnutrition. This is reflected by various indicators of anthropometric status and by multiple micronutrient deficiencies, particularly in respect of vitamin A, iron and zinc. The figures may not be overwhelming for the country as a whole (compared to other developing countries, particularly in Africa), but for certain provinces and areas within the provinces there is reason for concern. The situation is exacerbated by the double burden of malnutrition, namely overweight, with a huge proportion of South African adults and an increasing number of children who can be classified as overweight and obese.

There is general consensus that addressing nutrition problems requires holistic and multi-sectoral interventions, and that the focus should be on addressing the immediate, underlying and basic causes of the manifestation, i.e. the various forms of malnutrition. Reducing food insecurity by increased food production through a variety of approaches is one of the options. Focusing on increased and more efficient food production will create a “win” situation, and this was the primary aim during the years of the Green Revolution. This aspect has again been emphasised as of the highest priority for the African scenario, because it has been claimed that an African farmer produces between a third and a quarter of the production of his counterpart in Asia for the same crop (SCN, 2004:9).

Sustainability should be the criterion by means of which all nutrition interventions should be evaluated. Environmental sustainability of production as well as of consumption (dietary) patterns – referring to a “people” dimension of sustainability – should be kept in mind when nutrition interventions are planned and implemented. Programmes that are sustainable will lead to a “double win” situation.

Recently the social dimensions of reduction of poverty and under-nutrition have increasingly received attention, giving recognition to the human rights aspect regarding proper nutrition for all. By including the social component into the equation, the stage has been set for a “triple win situation” – the WIN-WIN-WIN – approach to addressing nutrition problems.

Water forms the basis of the fine balance between food production, nutrition, ecology and poverty. SIWI / IWMI (2004) therefore proposed a rethinking of the role of water, linking sustainable production to sustainable consumption. This is depicted in figure 5.1 and represents the so-called “double triple win”.

The lower triangle in figure 5.1 depicts the three components of sustainability in respect of food production. In order to achieve the MDG, food production must be economically viable, environmentally sound and acceptable to the people. In the upper triangle the pillars of sustainability are linked to sustainable consumption in terms of food choices/consumer demand. Again this must be economically viable and, therefore, this component coincides with the lower triangle. In addition, the growing number of people, many of whom do not produce food themselves, must have access to food, in other words, they must be food secure to be able to acquire the food they need and want. In the top left of the figure the diet as a whole and the health status of the individual are indicated, reflecting the ability of the body to absorb the nutritional value of the food consumed.

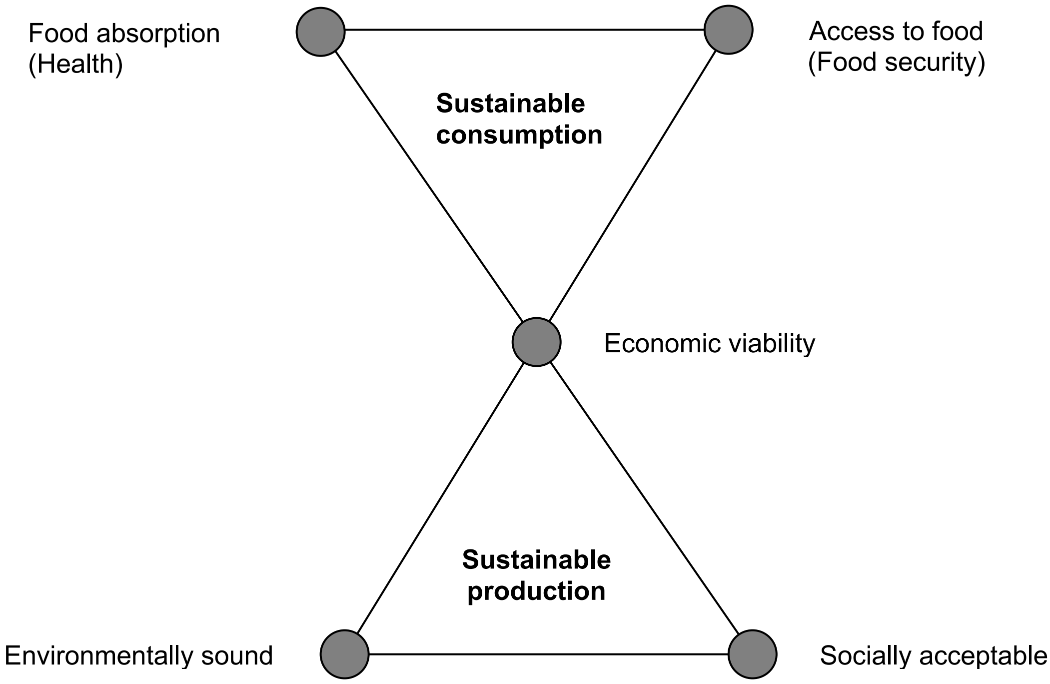


FIGURE 5.1: THE DOUBLE TRIPLE WIN: LINKING SUSTAINABLE PRODUCTION TO SUSTAINABLE CONSUMPTION
Source: SIWI/IWMI, 2004

One aspect that is often neglected is the interplay between production and consumption (diet preferences). Internationally consumer demand tends to move towards more animal-based diets with less indigenous crops, and, as shown in chapter 3, such diets are less water-productive. The observation that this also occurs in the most populated and water-stressed regions, that also tend to be the most affected by under-nutrition, is a worrying tendency.

On the other hand, indigenous and wild foods are receiving increasing attention for their nutritional potential and as part of the indigenous knowledge of people, both in developing and developed countries (e.g. Achidi *et al.*, 2005; Aphane *et al.*, 2003; Grivetti & Ogle, 2000; Husselman & Sizane, 2006; Ogle & Grivetti, 1985; Ogle et al., 2001a; 2001b; 2001c; 2003; Ogoye-Ndegwa & Aagaard-Hansen, 2003; Pardo-de Santayana *et al.*, 2005; Redzig, 2006; Weinberger & Swai, 2006). In South Africa the NFCS dataset showed that "wild leaves and spinach" made a significant contribution to the calcium, iron and vitamin A intakes of children < 9 yrs. The percentage contribution to total nutrient intakes was 8.0%, 10.6% and 13.5% for calcium, iron and vitamin A respectively, and in each of these cases the rank position was at least third (Steyn *et al.*, 2006b).

To investigate the nutritional value and water use of indigenous crops in terms of their potential to improve the nutritional status of South Africans as part of a sustainable livelihoods approach – that is the aim toward which this literature review eventually wishes to contribute!

"Fewer drops, more crops, most nutrition!"

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