1 Introduction

Currently, about one in three people worldwide, mostly women and children, suffer from diseases associated with malnutrition. Simultaneously, diseases associated with affluence, such as obesity, type 2 diabetes mellitus and heart disease, are on the rise not only in developed but also in developing countries, creating a double burden of nutrition. While the causes of malnutrition are complex, a leading cause is suggested to be a general simplification of diets; in short, declining diversity may lead to a decline in nutrition quantity (Bioversity International 2009).

In fact, it was observed that the so-called "food baskets" of Zambia (Luapula Province) and Tanzania (Rukwa Region), where there is a high degree of market-oriented maize mono-cropping, are, at the same time, the regions with the highest prevalence of malnutrition (Bellin-Sesay 1995). It is generally acknowledged that malnutrition – either micronutrient deficiencies or an imbalance in nutrient intake resulting in obesity – is, amongst others, caused by declining diversity in traditional food systems when these are being replaced by mono-cropping agriculture (Frison 2007). Yet, in many African farming systems, polyculture is the norm. The latter can be defined as a traditional strategy to achieve yield advantages as well as yield stability, an optimal exploitation of resources, reduction of pests and disease occurrence and, thereby, minimisation of risk, efficient use of labour and dietary diversity (Liebman 1995).

A high level of agrobiodiversity, besides providing nutritional diversity, is considered as a valuable resource in supplying the necessary nutrients for a health-oriented human diet. In fact, nutrition security addresses not only the access to but also the utilisation of food. One important underlying factor of nutrition security is a certain degree of diversity in the available food with its macro- and micronutrients (Bouis and Hunt 1999).

The project 'Promotion of Neglected Indigenous Leafy and Legume Vegetable Crops for Nutritional Health in Eastern and Southern Africa' (ProNIVA), in which the present study was integrated, focused on the improvement of household food security of resource-poor groups in Tanzania, Rwanda, Uganda and Malawi. Thereby, safeguarding biodiversity of indigenous vegetables, the promotion of production and consumption of the latter, and the establishment of improved cultivation practices together with the provision of higher quality seeds of indigenous vegetables, in order to stabilise farmers' incomes and nutritional health, were the main goals. Next to the evaluation of nutraceutical values of indigenous vegetables, nutritional health of people in the researched areas was assessed; associations between the availability of indigenous vegetables, their diversity, production, consumption and the nutritional status of people was investigated; the latter was the central topic of the present study in Tanzania and was expanded beyond indigenous vegetables, including all other vegetables as well as all foods in general.

Several studies have investigated the link between farming or home-gardening and nutritional health, with positive results. A study in Kampala, Uganda, for example, suggests that child

nutritional status (height-for-age) was significantly higher among households that farmed. Furthermore, among lower-socioeconomic status households, there was a significantly higher prevalence of moderate to severe malnutrition among children from non-farming households compared to those from farming households (Maxwell 1998). In Bangladesh, a large-scale home-gardening project found that families growing both more fruits and vegetables and a larger variety of fruits and vegetables, were likely to have a higher intake of vitamin A (Helen Keller International/Asia Pacific 2001). In several Asian countries, it was calculated that vegetables are an efficient source of micronutrients, both with respect to their unit cost of production and per unit of land required (Ali and Tsou 1997). Even where there is no evidence of a direct nutritional impact, farming and especially home-gardening can indirectly impact on nutritional status by increasing the income of the female farmers (Reynaud 1989).

Increased fruit and vegetable consumption has been widely promoted because of the provision of micronutrients as well as of many bioactive phytochemicals associated with health maintenance and prevention of chronic diseases (Steinmetz and Potter 1996). Greater fruit and vegetable consumption can, in fact, help address the double burden of micronutrient deficiencies and chronic diseases. Furthermore, diets rich in micronutrients and antioxidants are strongly recommended to supplement medicinal therapy in fighting HIV/AIDS. (Friis 2002)

Within the present study, firstly, the hypothesis was tested, that a high vegetable diversity available (“production”) results in high dietary diversity (“consumption”) in different districts of rural Tanzania. It was also of interest whether especially a high vegetable diversity was of advantage for or had a direct influence on nutrition, and which linkages existed between production and consumption. As other studies have already established these links for different regions, it was also considered important to investigate possible reasons for these links or reasons why there were no associations. Furthermore, as the integration of nutrition and agriculture is necessary but often highly neglected, to understand the linkages between the diversity of foods in the field and on the plate was one important focus.

Secondly, in order to test the hypothesis that a high cropping diversity and a high dietary diversity resulted in a good nutritional health status, production as well as consumption were linked to nutritional health of participating women, namely to their body mass index (BMI), vitamin A and iron status.

While this study focused, on the one hand, on single food groups, health problems and nutrients, on the other hand, a more holistic view on dietary diversity/food variety and dietary patterns and their relation with nutritional status and vegetable production was taken. For some time already, nutritionists have been advocating for a change in the focus of the dietary recommendations from nutrients to patterns of dietary intake (Sichieri 2002). Especially dietary intake in relation to diseases is highly complex, as foods contain many nutrients and foods are eaten in combinations

and, thus, it is difficult to credit effects to single dietary components (Schulze and Hoffmann 2006). Therefore, investigating the links between nutritional health and food intake is a challenge, yet, it is an important and necessary step in order to gain more knowledge about nutrition security and its underlying causes.

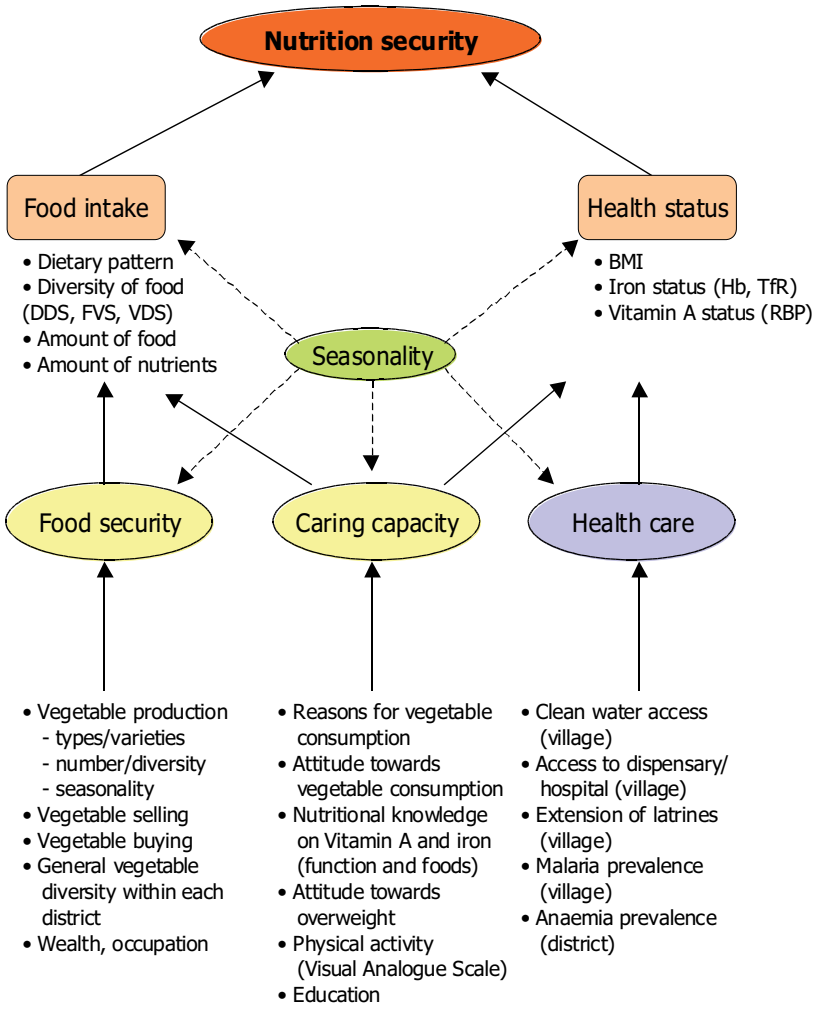

Figure 1.1 Model of nutrition security and underlying factors showing available data from the present study in Tanzania (modified after UNICEF (1998) and Krawinkel (2006))

When organising the different areas of this study, a model of nutrition security (modified after UNICEF(1998) and Krawinkel (2006)) was applied (Figure 1.1). This model gives a holistic view of all factors influencing nutrition security. However, as not all of these factors were surveyed within the present study (e.g. “health care” variables only for whole villages, not for single participants), the model was simplified for this study showing the three areas explored in Tanzania (Figure 1.2). Thereby, “production” includes all activities related to vegetables “in the field”, while “consumption” stands for vegetable and general food intake. The socio-economic parameters as well as other influencing factors, grouped under “caring capacity” in the nutrition security model, are expected to

influence all three areas directly and are clustered as socio-economic factors, knowledge and attitudes. The arrow from “production” to “nutritional health” is only dotted, as a direct link was expected to be less likely, yet, the link was tested with the present data.

Though being highly complex, the aim of this study was that each discussion chapter could be understood independently and, therefore, other chapters are strongly cross-referenced to. The present study can not give representative results for the whole of Tanzania, yet, it identified relevant aspects of the investigated themes and emphasises the importance of true interdisciplinary research.

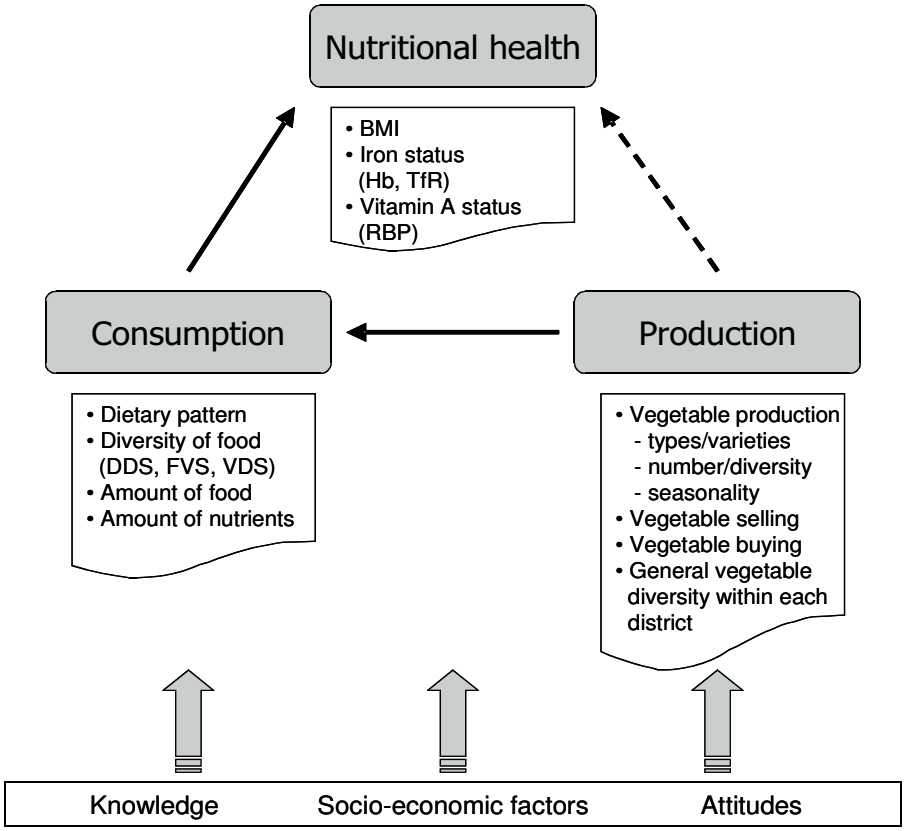

Figure 1.2 The three main areas investigated within the present study and influencing factors

2 Materials and Methods

A cross-sectional sequential study was performed with different survey methods. The main part of the survey was an individual interview on different topics; further, the health status of study participants was measured by various means. While some measurements were performed and questions asked only once, others were repeated three times within one year. Thus, the design can also be called cohort or follow-up study (Lang and Secic 2006) as always the same participants were included. Ethical clearance for this study was granted by the ethical clearance committee of the faculty of medicine at Justus-Liebig-University of Giessen, Germany. Furthermore, the study was approved and permission for the research was given by Sokoine University of Agriculture, Morogoro, Tanzania.

2.1 Research location and participants

The present study was part of the ProNIVA project and built i.a. on its baseline survey in 2003 (Keller 2004), e.g. regarding the selection of districts and villages. The time for conducting the surveys was chosen as to cover three different seasons within a whole year, namely first the dry season (DS) during June/July; second the short rainy season (SR) during November/December; and third the end of dry and beginning of the long rainy season (LR) during March/April. Yet, rain fall patterns are different for different areas of Tanzania (see below). While the year – here 2006 and 2007 – obviously will be crucial for the results, especially those regarding vegetable cropping, in the following only the abbreviations of the months are applied together with the abbreviation for the seasons, thus, Jun/Jul (DS), Nov/Dec (SR) and Mar/Apr (LR).

2.1.1 Selection of villages

The districts and villages for this study were those already visited within the ProNIVA baseline survey (Keller 2004; Weinberger and Msuya 2004), however, a smaller sample was chosen out of all participating villages. Selection criteria were the location to cover best the whole district, how cooperation of village members was during the baseline survey and, in terms of Kongwa, if irrigation was available (Table 2.1).

Rainfall patterns were said to be bimodal in all chosen districts, however, Singida is located in a transition zone between a bimodal and a unimodal rainfall regime. Still, it was assumed that all chosen areas receive short *vuli* rains from October to December with a minor cropping season, and long *masika* rains from March to May providing the main cropping season (USDA 2003).