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Production and processing of foods as core aspects of nutrition-sensitive agriculture and sustainable diets

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Abstract Some forms of malnutrition are partly due to agriculture not having nutrient outputs as an explicit goal. A better understanding of what is required from agricultural production and food processing for healthy and sustainable diets is needed. Besides nutritional quality or nutrient output, important factors are: water, soil, health hazards, agrobiodiversity and seasonality. Therefore, possible interactions among constituents of the food chain – human health, the environment, knowledge and education – should be considered from a systemic perspective. Nutrition-sensitive agriculture needs to consider and understand the role of biodiversity in improving dietary quality and dietary diversity as well as seasonality in food supply. Apart from improving agricultural systems in order to close the nutrition gap, efficient storage and food processing technologies to prolong shelf-life are required. If processing is poor, high food losses can cause food insecurity or increase the risk of producing unsafe and unhealthy food. Food storage and processing technologies, particularly at household level, are challenging and often not applicable to traditional crops. In order to achieve the aims of nutrition-sensitive agriculture, it is necessary to comprehend its complexity and the factors that influence it. This will require a trans-disciplinary approach, which will include the three sectors agriculture, nutrition and health at research, extension and political levels. Ensuring that farmers are knowledgeable about production systems, which sustainably provide adequate amounts of nutritious food while conserving the environment is an essential part of nutrition-sensitive agriculture. At the same time, for the benefits of nutrition-sensitive agriculture to be realized, educated consumers are required who understand what constitutes a healthy and sustainable diet.

Keywords Dietary diversity · Crop diversity · Food processing · Sustainable diets · Trans-disciplinarity · Agrobiodiversity

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Introduction

Lack of affordable and adequate food at the household level is considered to be one of the main causes of hunger and malnutrition. Malnutrition occurs in different forms, namely undernutrition, micronutrient deficiency, and over nutrition leading to overweight and obesity. Different forms of malnutrition as well as diet-related diseases, leading in countries at all income levels to high social and economic costs (FAO 2013a), can be addressed through healthy and balanced diets. Maximising the nutrient output of farming systems for a culturally acceptable and balanced diet, however, has unfortunately never been an objective of agriculture, rather the objective has been to maximise production while minimising costs (Welch 2008). Agricultural research and production has focused on increasing staple food production to deliver carbohydrates (Green Revolution). Companies and breeders have influenced food crops, both through the introduction of varieties requiring certain inputs and by encouraging the growth of crops that may be industrially processed (Dinham and Hines 1983). In some areas, replacement of traditional crops, such as legumes, by high yielding modern varieties has badly affected food resilience through the incorrect application of

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fertilizers and pesticides owing to lack of knowledge or financial resources, resulting in low or no yields at all (Lall 1993).

In 1999 Ross Welch and Robin Graham had already called attention to the fact that 'Hidden Hunger' is partly due to agriculture not having nutrient output as an explicit goal and partly due to nutrition and health communities having used agriculture too little as a primary tool in their nutrition programmes. They advised searching for sustainable solutions to such failures through holistic food-based systems and to focus on linking agricultural production to improvement of human health, livelihood and wellbeing. (Welch and Graham 1999). Several pathways by which agriculture can affect nutritional outcomes have been repeatedly suggested, such as increasing food security and income, making prices for food affordable, increasing women's social status and time availability as well as their health and nutritional status (Ruel et al. 2013; Gillespie et al. 2012). Only recently, an extensive review of available guidance on agriculture programming for nutrition has resulted in 10 key recommendations for improving nutrition through agriculture (Agriculture-Nutrition Community of Practice 2013). Three of the recommendations highlighted were to "maintain or improve the natural resource base (water, soil, air, climate, biodiversity)", to "facilitate production diversification, and increase production of nutrient-dense crops and small-scale livestock" and to "improve processing, storage and preservation" (Agriculture-Nutrition Community of Practice 2013). These areas will be discussed in more detail in this paper, together with possible interactions at a systemic level of the food chain, human health and the environment (Fig. 1). From this discussion, the barriers and entry points to nutrition sensitive agriculture will emerge.

As part of a series of papers on nutrition-sensitive agriculture this paper is reinvestigating what is needed from agriculture from the nutritional-health angle and how principles of nutrition-sensitive agriculture are linked to food based approaches and sustainable diets; the focus will be on both agricultural production and food processing while other papers within this series focus, for example, on gender and human development (Beuchelt and Badstue 2013) and plant breeding for nutrition-sensitive agriculture (Christinck and Weltzien 2013).

The concept of nutrition-sensitive agriculture has been described in the first paper of this series by Jaenicke and Virchow (2013), stating as its aim to "narrow the gap between available and accessible food and the food needed for a healthy and balanced diet for all people" and highlighting the different dimensions, namely health, education, economic, environmental and social aspects. Another concept, that of sustainable diets, does not include "education" explicitly but comprises, in addition, the aspects of cultural acceptability and nutritional adequacy while focusing on sustainable solutions. It is defined as follows: "Sustainable diets are those diets with low environmental impacts which contribute to food and nutrition security and to healthy life for present and future generations. Sustainable diets are protective and respectful of biodiversity and ecosystems, culturally acceptable, accessible, economically fair and affordable; nutritionally adequate, safe and healthy; while optimizing natural and human resources" (FAO/Bioversity 2012).

Linking the two concepts requires that agriculture, with its multifunctional character, needs to be both nutrition-sensitive and sustainable. When moving along the value chain, agriculture will encounter its limits at some point where food

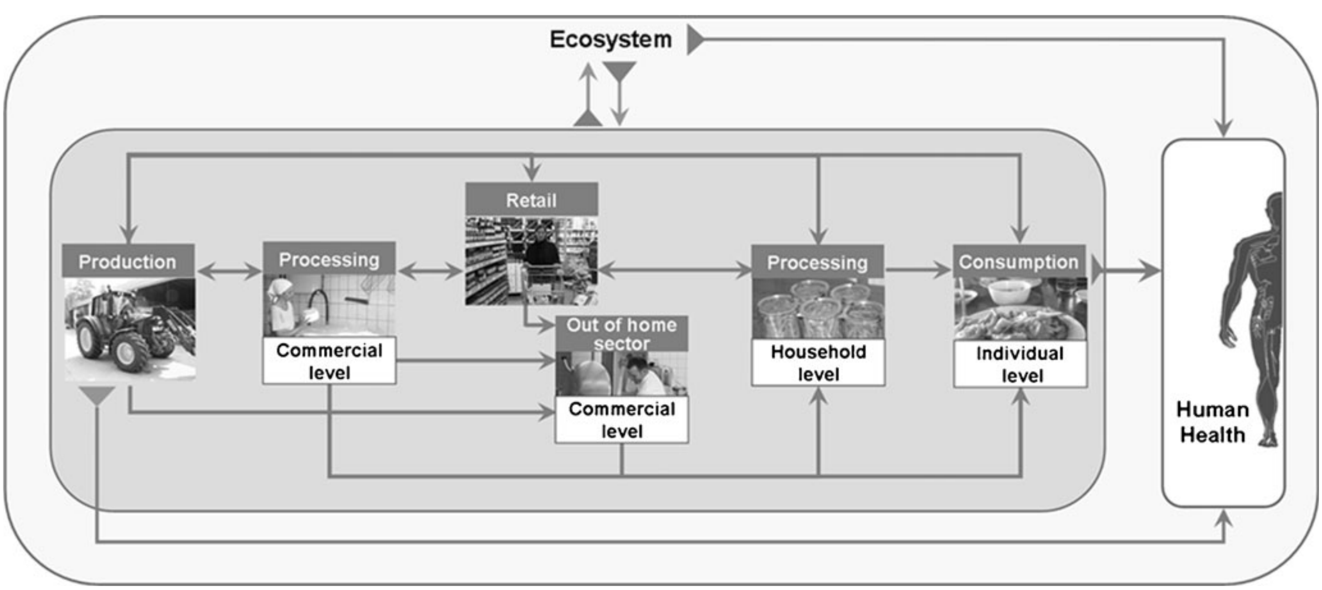

Fig. 1 A systemic view of the food chain focusing on human health (modified from Schneider and Hoffmann 2011a, b)

processing starts. While a fluent transition between the different fields of responsibilities without clear boundaries exists, it is important to investigate explicitly the food processing part for its nutrition-sensitiveness similarly to that of agriculture. Therefore, while the first section of the paper will summarise some background information on nutritional requirements, the next two sections will focus on aspects of production and processing that ensure nutrition sensitivity and sustainability of diets. The last section will discuss the education and knowledge needed to achieve nutritionally sensitive agriculture.

Nutritional requirements from production and processing

From a nutritional point of view, agricultural products are commonly divided into food groups, emphasizing their importance in supplying specific nutrients. Adequate intakes of nutrients for a healthy life are estimated by various nutrition societies and institutions (DGE et al. 2012; USDA/USDHHS 2010; Nishida et al. 2004) and minima are recommended. Actual intakes are presented as percentages of these minima (Welch 2008).

The supply of nutritionally adequate foods to the global population is still challenging. Although supplementation and fortification of food are well-established methods to cover the micronutrient needs in our diets, iodine, vitamin A and iron deficiency rates, for example, are still high, although they are targeted in various programmes (Andersson et al. 2012; Micronutrient Initiative 2009; WHO 2011). Other well-known nutrients, such as zinc, have received less attention although elimination of zinc deficiency improves health status considerably. In many low income countries (LIC), staple diets are predominantly plant based and the intake of rich sources of readily available dietary zinc such as red meat, poultry and fish, is often low because of economic, cultural, or religious constraints. As a result, the amounts and/or bioavailability of zinc from such diets are low and frequently the primary cause of zinc deficiency (Gibson 2012).

It has long been recognised that a balance of nutrients forms the basis of a healthy diet, and on-going research continues to further our understanding in this area (Waage et al. 2011). Several studies also investigated possible links between dietary patterns and health, acknowledging that nutrients are ingested within diets (Lee et al. 1991; Hunter et al. 1996; Wakai et al. 2000; Hu et al. 2000; Kris-Etherton et al. 2002; Cho et al. 2003; Frazier et al. 2003; Weikert et al. 2005; WCRF 2007; Engeset et al. 2009; Prentice et al. 2007; Arimond et al. 2010; Jordan et al. 2012). Most of these studies relied on observing dietary patterns for which foods are grouped according to their nutrient value and not according to biological classification, cropping system or plant parts used. These must be considered when agriculture encounters nutrition and vice versa to ensure a common understanding of terms. As a healthy diet needs to include foods from all different food groups, nutrient adequacy of the diet might be described as individual dietary diversity, i.e. the number of food groups consumed during the day (Kennedy et al. 2009).

Food selection by individuals is influenced by climate, culture, food availability, education, socioeconomic status, and tradition, and no single dietary pattern is correlated with good health. The character of a dietary pattern depends on the locally available foods, on the local market structure, on socio-cultural habits as well as affordability of and access to food, thus, on all components forming a sustainable diet. It is also characterized by specific combinations of foods from various food groups. Therefore, generalization is possible only on a regional level. However, dietary patterns can be used to describe the nutrition transitions observed in many low income countries (Popkin 1994) such as Tanzania (Keding et al. 2011).

Direct measures of food consumption collected by nationally representative dietary surveys are required to accurately understand diet patterns within and between populations, but can be prohibitively costly and lengthy to conduct in most settings (Waage et al. 2011). The estimation of the individual quantities and the actual nutrient content of the foods consumed are the main challenges in these surveys. Only limited data on food composition is available about foods from the tropical and subtropical countries. In order to allow large scale differentiation of dietary behaviour, diet quality and nutrient intake in populations, individual dietary diversity scores for different household members have been developed (Arimond et al. 2010; FAO 2011). Beside the score number, the validity of this metric is highly dependent on the types of food groups the score is composed of and whether adequate nutrient supply is achieved (Keding et al. 2012).

Results of various surveys show that the diversity of diet in many low income countries is poor and especially lacking in fruits and vegetables. Besides non-acceptance (e.g. considered as "poor man's food", unknown nutrient value), reasons include **production issues** (e.g. more time consuming than staple crops, poor availability of seeds/seedlings of local fruit and vegetables in some areas) and **post-harvest and processing challenges** (e.g. spoil easily if not handled correctly during harvesting, storage and marketing). However, in addition to access to appropriate food, a healthy environment includes access to safe drinking water and sanitation facilities, basic health services, and maternal and child care. The absence of these are other important factors that underly malnutrition and death at the micro, meso and macro level (UNICEF 1990; Gross et al. 2000; Müller and Krawinkel 2005) and need to be considered when discussing possible entry points for nutrition sensitive agriculture.

Food production

There are five main areas that are connected with food production and directly or indirectly influence nutritional health: water, soil, agrobiodiversity, health hazards and seasonality (Fig. 2). The aim of the following discussion is to understand what factors needs to be implemented in order to accomplish nutrition-sensitivity and consequently contribute to balanced and healthy diets of the whole population. For example, in a 6-year programme in Northern Laos water safety and an improved water supply enhanced the nutritional status of a community more significantly than increase in agricultural production (Kaufmann 2009).

Water requirements

Water, often considered a renewable resource, is finite in terms of the amount available per unit of time in any one region (Pimentel et al. 2004) and the availability of safe drinking water is essential for human health and nutrition. Poor access to safe drinking water or poor hygiene due to lack of water are often the causes of water borne diseases such as diarrhoea. Therefore, it is essential that the water be of sufficient quality to prevent such diseases (Gleick 1996). The human body (average size of 70 kg body weight) requires, as a minimum, an average of 3 l/day for survival and rather more in tropical and subtropical climates. This amount does not include water used for food production and preparation or hygiene practices. Water availability may be affected by conflicts, as water itself is often a cause of these, particularly in border areas (GWP 2011; Pimentel et al. 2004) consequently affecting food production. Also, water pollution is a serious problem in areas of intensive agriculture with high inputs of fertilizers and pesticides (Benotti et al. 2009), possibly causing serious health problems, such as stomach cancer (Van Leeuwen et al. 1999).

In areas of scarcity, water requirements for agricultural production are in competition with those for basic human needs. Water requirements of crops (dry crop yield) and animals, which are non-recoverable, range from 272 l/kg for millet to 2,000 l/kg for soybeans and from 3,500 l/kg for broiler chicken to 51,000 l/kg for cattle (Pimentel et al. 2004). Approximately 70 % of the fresh water drawn per year is consumed by the world's agriculture but this can be reduced by applying appropriate agricultural production methods and soil management techniques. These allow retention of water in the soil, reduction of irrigation demand and prevention of soil erosion. In turn, these reduce water run off and avoid the elution of nutrients, fertilizers and pesticides into the surface and groundwater systems (Pimentel et al. 2004).

Soil fertility and quality

Complex chemical, physical and biological processes, carried out by the soil biota, affect the availability of nutrients in the soil and the incidence of soil-borne plant and animal pests and pathogens. These in turn affect the quality of the soil, the quality and yield of crops and the general health of ecosystems. Plants can only use those nutrients that are easily available or are in specific chemical forms and these are influenced by the soil biota, including plant roots. These are particularly important in areas where chemical fertilisers are not or cannot

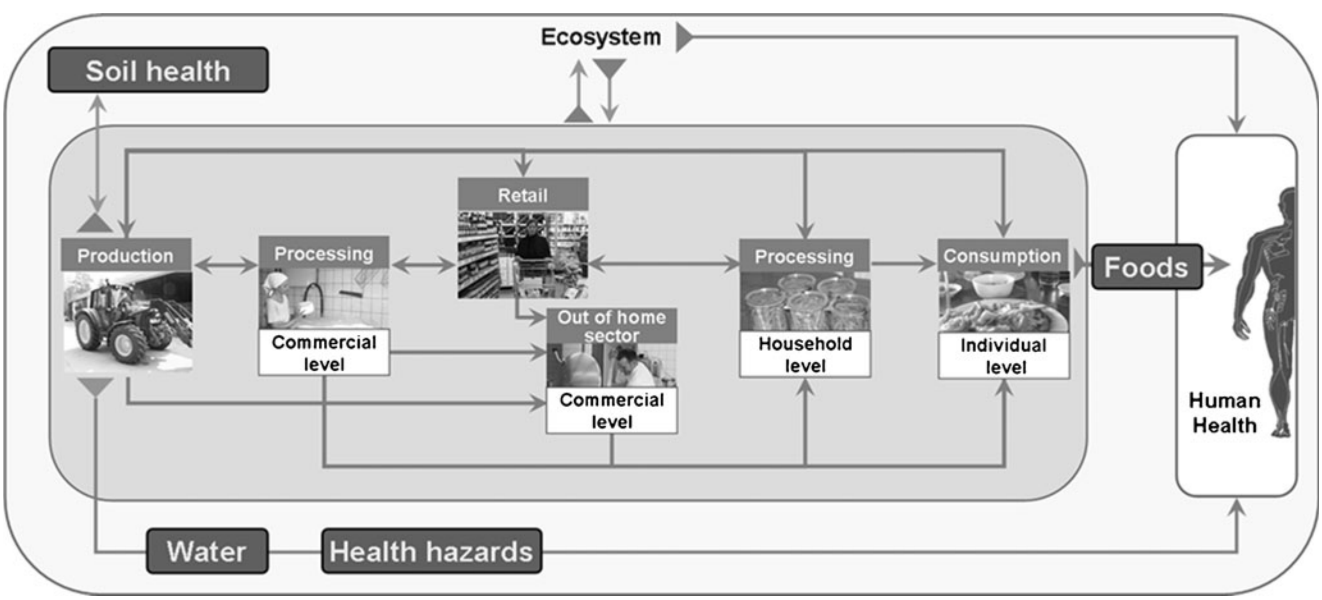

Fig. 2 The food chain including central effects that need to be addressed by nutrition-sensitive agriculture (modified from Schneider and Hoffmann 2011a, b)

be applied as is often the case in developing countries (Jeffery et al. 2010).

Soil degradation affects human nutrition and health directly through reduction in the quantity and quality of food and indirectly through loss of household income, additional land area required to compensate for the loss of production, and also through pollution of soil and soil water with consequent severe impacts on human health. Although strong links between soil health and human health exist, information about the relationship between soil degradation, food production and its nutritional quality is scarce, especially in South Asia and Sub-Saharan Africa (SSA) where the problem is most severe (Lal 2009). Nevertheless adoption of proven soil management techniques has the potential to increase substantially the production of staples in SSA and, in addition, improve their nutritional quality (Lal 2009). Not only must their nutritional value be considered but also whether undesired elements accumulate in the crop in excessive amounts. This could occur when agricultural fields are close to industries or smelters that produce waste waters contaminated by heavy metals (Cui et al. 2004). Irrigation with waste water in urban agriculture presents similar problems (Kumar Sharma et al. 2007)

While the main research focus has been on staple crops so far, it can be concluded that the maintenance of healthy soil is one aspect of nutrition-sensitive agriculture, which can contribute to the improvement of human nutrition in general.

Agrobiodiversity

Agricultural biodiversity – agrobiodiversity for short – can be defined as the diverse traits exhibited among animals, crops and other organisms used for food and agriculture, as well as the web of relationships of these forms of life at ecosystem, species and genetic levels. It is the basis of the food and nutrient value chain and its use is important for food and nutritional security (Frison et al. 2006). Out of the 10,000 plant species that can be used as foods for humans only about 150 have been commercially cultivated and only four–rice, wheat, maize, and potatoes–supply 50 % of the world’s energy needs (FAO 2010a). Here lies a great potential among heretofore under-utilized species for contributing to food security, health, income generation and ecosystem services.

Nutrition-sensitive agriculture requires consideration and understanding of the role of agrobiodiversity in improving dietary quality and dietary diversity, i.e. the consumption of a wide variety of foods across nutritionally distinct food groups. A lack of diversity is a crucial issue, particularly in the developing world where diets consist, to a great extent, of starchy staples and where nutrient-rich foods such as those from animal sources and fruits and vegetables are less available or accessible (Bioversity 2011; Keding et al. 2011; FAO 2013a). On the other hand, it is acknowledged that the consumption of a variety of foods across and within food groups almost guarantees adequate intake of essential nutrients and important non-nutrient factors (Bioversity 2011; Frison et al. 2006, 2011). While several research studies have already well documented the links between dietary diversity and diet quality and nutritional status of children (Arimond and Ruel 2004; Kennedy et al. 2007; Rah et al. 2010; Savy et al. 2008), as well as associations between dietary diversity, food security and socioeconomic status (Hoddinott and Yohannes 2002; Ruel 2003; Thorne-Lyman et al. 2009), it is now crucial to understand how agricultural systems and the benefits derived from agrobiodiversity affect consumption patterns, nutrition and the health status of people, particularly in the developing world. In addition to productivity enhancement through production diversification, reduced seasonality (discussed below), adaptation to climate change and women’s empowerment (discussed by Beuchelt and Badstue 2013) are also important (FAO 2013b).

The question arises which approaches are available to find a suitable production system for a certain food system that would ensure nutritional adequacy of households or of all members of a society in a sustainable and healthy manner. When the type and amount of nutrients produced in each food system is known, an optimisation model using existing resources could analyse which cropping strategies might improve the nutritional quality of people’s diets (Amede et al. 2004).

To emphasise the availability of nutritionally distinct crops in a cropping system in order to address nutrition security issues, the concept of nutritional functional diversity will be highlighted. Instead of looking only at the relationship between crop diversity and nutrition, DeClerck et al. (2011) used the content of seven important nutrients for categorising edible plant species. They confirmed that the capacity of a farm to provide a wide range of nutritional functions to households increases with increasing agrobiodiversity. More remarkably, it was found that a farm could have many species but low nutritional diversity and vice versa, though species richness and functional richness were correlated (DeClerck et al. 2011). Of course, the links between human nutrition and agrobiodiversity remain challenging, as the owners of a specialised farm earning adequate cash through marketing of their produce can maintain a highly diversified and adequate diet through purchasing foods. Still, in order to overcome malnutrition, an interdisciplinary approach linking agriculture and ecology to human nutrition and health, also described as “econutrition”, is needed. These disciplines share common concerns such as loss of biodiversity, decline in soil fertility, decrease in food production and increase in malnutrition (Deckelbaum et al. 2006).

Possible health hazards from agricultural products

Animal or plant diseases that are followed on a large scale in the agricultural sector are usually those with a high economic impact such as rinderpest in cattle and blight and rust in crops. Diseases or other health hazards that are spread through the food chain and can affect human health receive rather slow responses. In general, in high-income countries the trend leans towards "first satisfying our food quantity needs before asking about quality" (Waage et al. 2011).

High pesticide concentrations in foods resulting in acute poisoning in low income countries have serious effects. In 2008, Nigeria reported 112 cases of poisoning through food, two children even died and 120 cases of possible poisoning through beans contaminated with Lindane (IRIN 2008; OCA 2008; PAN Germany 2011). In addition to consumers eating contaminated foods, farm workers are at risk when handling and applying chemicals in certain food production systems and especially so when protective clothing is not available. In general, little is known about pesticide exposure and health among farmers in low income countries. However, various epidemiological studies show increased risks for various cancer types among women and men who have been exposed to pesticides either in production plants or during application of these chemicals (Garcia 2003).

A number of pesticides, used in agriculture, have the potential for high health risk. Possible pathways of poisoning are through direct contact with the skin during preparation or distribution and drifting or indirect contact through polluted drinking water. Miscarriages attributed to the application of pesticides by women, reduced fertility in men and an increased risk of Parkinson's Disease have often been described (Baldi et al. 2003; Bell et al. 2001; Oliva et al. 2001). In 1990, WHO and UNEP estimated that three million people were poisoned and 220,000 people died from pesticide use each year and most were farmers or farmworkers. A more recent estimate by the World Bank (2008) suggests that this has increased to 335,000 people, two thirds of them in low- and middle income countries (Waage et al. 2011).

When livestock systems become more intensive and livestock value chains become longer and more complex, livestock diseases usually become more problematic (Rushton 2009). In high-income countries, the response to animal diseases that have serious impacts on human health but cause less dramatic economic losses regarding production, such as food-borne infections and zoonotic diseases, have been receiving strong interest only recently (Waage et al. 2011).

Another issue in nutrition-sensitive agriculture is the use of antibiotics, both in humans and in animals for prophylaxis and in animals for growth promotion (Wise et al. 1998). Globally, an estimated 50 % of all antimicrobials serve veterinary purposes (Teuber 2001) and antibiotic-resistance is a widespread challenge and increasing problem in African countries. In Ghana, a study recently called for the need of an antibiotic-resistance programme (Donkor et al. 2012) for which the agriculture and the health sector would have to work closely together.

These environmental burdens of disease are associated with changes in agricultural practice and policy (Prüss-Üstün et al. 2006). At the same time, agriculture is the main livelihood strategy for the poor and it is, thus, the poor who are disproportionately affected by these health problems. Persistent health risks associated with agriculture such as water-related, food-borne, and zoonotic diseases require joint solutions and cooperation between the agriculture and health sectors (IFPRI 2011). Consequently, agriculture does not only need to be nutrition-sensitive but also health-sensitive (Prüss-Üstün et al. 2006).

Balanced diets throughout the year

The UN System High Level Task Force (HLTF) on Global Food Security claims that enabling "all people to secure year-round access to the varieties of food required for good nutrition" would be an important means by which hunger and malnutrition could be ended (UN 2012). While already in 1996 the definition of "Food Security" included the concept of seasonality ("at all times") (FAO 1998), the UN HLTF emphasised again that national goals for reducing hunger and improving nutrition need to include "ensuring consistent availability and accessibility of sustainably produced, nutritious and safe food in local markets" (UN 2012) as also suggested by the World Bank (Herforth et al. 2012; World Bank 2013).

Pre- and post-harvest season measurements are usually undertaken; note, however, the "harvest season" is often defined only in terms of staple foods but fruits, vegetables and animal products may follow different time patterns. Seasonal food insecurity is not only a short-term problem but frequently has lasting effects that create and reinforce poverty. In a study in Tanzania, for example, past food security was associated with current dietary intake and own perceived health and wealth (Hadley et al. 2007). The study team concluded even though the food insecure season is of a limited duration, households may become trapped in a cycle of poverty. Consequently, it is highly important to support households in creating buffering capacities to tide them over temporary shortages.

Seasonal calendars can provide a good overview of times when foods may be harvested and are, thus, available. They also indicate periods when they cannot be harvested and must, therefore, be stored for availability during that time. In 2012, FAO launched a "quick reference calendar" for 43 African countries and for different crops in various agro-ecological zones (FAO 2012a). From this database a calendar for the major crops in the lower-midland zone 1 of Kenya was created

(Table 1) to show the availability of different crops sorted by food groups. In this example, a gap for green leafy vegetables was identified during February, March and the beginning of April as well as the end of August and the beginning of September. Although the availability of leafy vegetables is high in Kenya (Maundu 1997), the diversity as well as the required amounts need to be considered in order to determine whether the different species can fill this seasonal gap. Secondly, other foods with a similar nutrient content, for example, similar levels of vitamin A, such as roots or tubers could be considered for filling this gap. Thirdly, if no fresh products are available from this area at that time, foods can be imported from other agro-ecological zones. However, adequate supplies must exist and these usually highly perishable products must be able to be transported and stored for an appropriate time. Timing of seasonal highs and lows of fruit and vegetable market prices is very similar across different markets in Kenya, generally differing by only 1 or 2 months (Mathenge and Tschirley 2006), showing the limitations of national food markets.

Table 2 shows food supply data, calculated as national production minus export and the amount used for animal feed, plus import. Data from Angola, Cambodia and Kenya (Global Hunger Index 2011 (IFPRI 2012) 24.2, 19.9 and 18.6 respectively) are compared with the recommended daily intake of different food groups (DGE 2004; FAO 1997; USDA/USDHHS 2010). It is important to note that fruits and vegetables are listed together as well as animal source foods and beans/pulses. For all three countries fruit and vegetable supply is considerably below the desirable intake of 400 g/d or more, while fat and oil supply does not meet the recommended dietary intake in Angola. Milk supply seems to be sufficient in Kenya but not in the other two countries, yet, acceptability of milk and milk products in local diets needs to be considered. Similarly, while meat, fish and eggs seem to be available in sufficient amounts in aggregate, their distribution among the inhabitants of the countries may be uneven. The validity of this may be questioned as using food supply or food balance sheet data from FAO as proxy measurements of food consumption have substantial limitations (Waage et al. 2011). While the FAO data give a first estimate of the situation they do not capture less popular or wild foods, which often contribute considerably to food security. Food availability and food consumption therefore need to be surveyed on a regional level in order to be able to provide tailor-made solutions for specific areas and times e.g. seasonal nutrition gaps. Regarding fresh food supplies it is necessary to preserve or process these so that they can be made available during non-harvest times or when trading is less feasible and/or too expensive for the consumer.

Nutrition-sensitive food production: entry points

Agriculture can use several approaches to improve the nutritional quality of food crops and output of agricultural systems but nutrition and health sectors need to be involved. Government policies must support these approaches and the profitability of participation in the relevant approaches must be

Table 1 Seasonal calendar of selected crops in the lower midland zone 1 in Western Kenya (FAO 2012a)

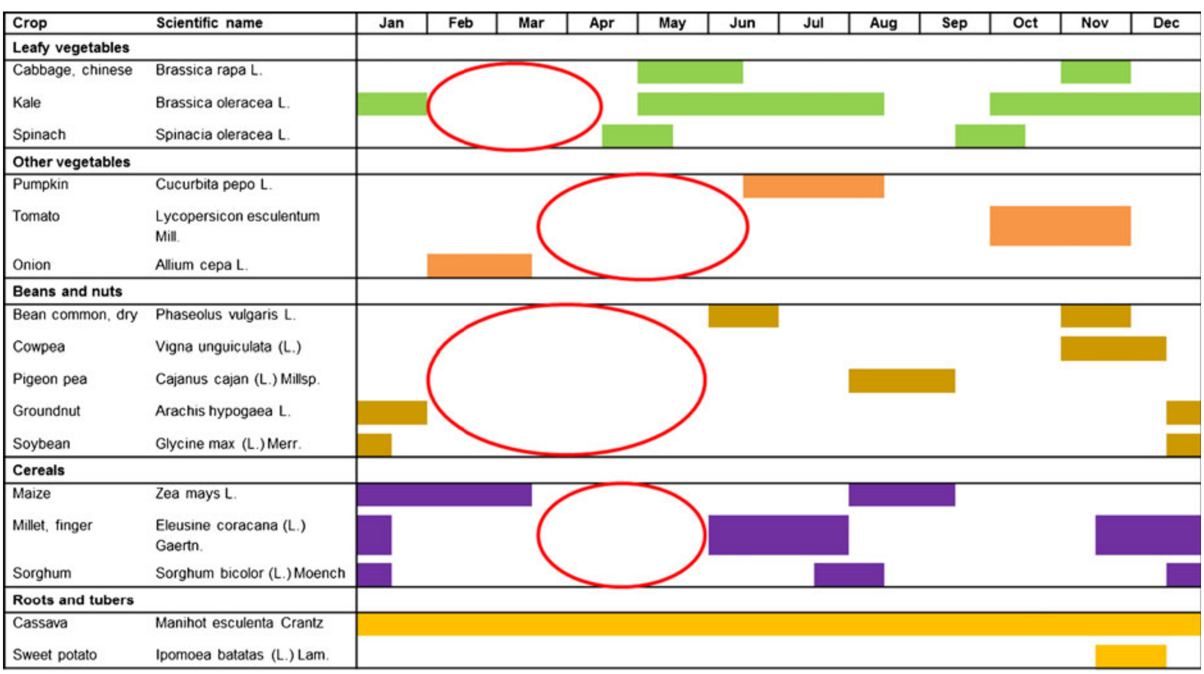

Table 2 Food supply in g/capita/d in different countries; average of 10 years from 2000 to 2009

	Angola	Cambodia	Kenya	Recommended daily intake in g/d[a]
Cereals, roots, tubers, plantains	378.7	500.1	398.2	300–500
Pulses/legumes	17.9	5.8	35.5	50–150
Animal source foods (meat, fish, eggs)	95	127	55	
Milk and milk products	38	11	232	250–350
Fats and oils	5.3	18.2	19.9	15–30
Vegetables	57.1	90.1	126.5	>400
Fruits	79.6	71.5	158.5	

FAOstat 2012

[a] Grams of food group per day for a standard person of 70 kg body weight/for a 2,000 calorie level (DGE 2004; FAO 1997; USDA/USDHHS 2010)

made clear to farmers (Welch 2008). This has been described in more detail in the first paper of this series "Entry points into a nutrition-sensitive agriculture" (Jaenicke and Virchow 2013).

Nutrition-sensitive agriculture needs to examine all food groups and production intensity at the regional level, especially fruits and vegetables, to ensure adequate supply in quantity and quality. The agriculture should build up market links to improve seed supply and other inputs where production is possible as well as supplying products to regions where these crops cannot be grown.

Another solution to facilitate the access to an energy and nutrient balanced diet is to promote home gardens with special emphasis on foods rich in certain micronutrients (Weinberger 2013). Food based approaches such as home gardens need well-designed nutrition and agriculture components as well as platforms for education and promotion activities in both sectors to be effective (Faber and Laurie 2011). Nutrition security is not only achieved by adequate food supply but also by ensuring adequate care, safe drinking water, healthy sanitation facilities and access to a health system (see for example the study in North Laos by Kaufmann 2009).

Agronomic practices that could be used to enhance the nutrient output from agriculture include fertilisers and soil amendments, crop variety selection, crop management, increasing the use of indigenous and traditional food crops with high nutritive value and appropriately designed cropping systems (Welch 2008). To optimize nutrition several organizations specifically recommend the on-farm production of legumes, horticultural crops, animal source foods and also biofortified crops (FAO 2013b)

Biofortification is the breeding of crops with increased nutrient content as opposed to the addition of nutrients after harvest. Advantages and challenges of biofortification are discussed in detail in another paper within this series by Christinck and Weltzien (2013).

Different agricultural systems are especially suited to maximise nutrient output and food diversity sustainably. For example, agro-forestry systems combine annual and perennial crops, often with multi-purpose usage; organic agriculture usually applies extended crop rotations and uses many different cultivars and breeds, often local or well-adapted landraces. Calculation of the Land Equivalent Ratio shows that many combinations of crops give higher yields compared to monoculture (Mead and Willey 1980). While inter- or polycropping is common on many smallholder farms in Sub-Saharan Africa in order to maximize the use of land, water and nutrients and to reduce risks (Graham et al. 2007), the interactions between crops and their effects on productivity still need to be better understood. Such understanding could help to shape a positive image of this most practical and productive cropping practice instead of it being regarded as a necessary but unwanted coping strategy (Herforth 2010).

Figure 3 compares organic and conventional agriculture according to their environmental effects. Organic agriculture was superior for most indicators, especially those regarding agrobiodiversity and thus, indirectly regarding nutrition and sustainable diets as well but it would have been interesting had yield been included in the figure. No difference between organic and conventional systems regarding water use was found.

Integrating legumes into cropping systems and dietary patterns

To conserve soil resources in low input agriculture, increase nitrogen inputs and recycle nutrients, integrating legumes into a farming system is one solution. Resource-poor farmers would most likely not adopt legumes solely for their beneficial ecosystem traits but would be interested in varieties that contain short-term nutritional and market benefits. Still, many studies focus only on the contribution of legumes to soil fertility and health and the general beneficial effects on crop productivity rather than human nutrition and health (Cakmak 2002). The production of fodder is another benefit of legumes which are often referred to as women's crop (FAO 2013b).

While the integration of legumes would create a win-win situation for both nutrition and agriculture, the long-term

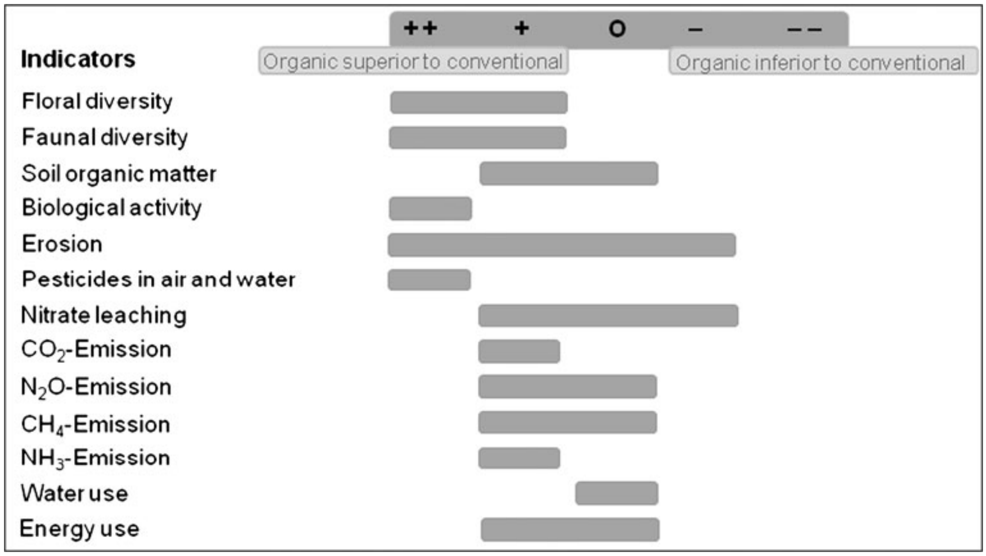

Fig. 3 Environmental effects of organic agriculture in comparison to conventional agriculture on the basis of 13 selected indicators (modified from Stolze et al. 2000)

impact of legumes will be determined by agronomic practices, for example, how residues are managed and by the extent and intensity of legume integration into cropping systems. Moreover, as they are mainly managed by women, the use of legumes, e.g. for land management, could possibly increase women's work load (FAO 2013b). In order to foster the diversification of cropping systems with legumes, farmers' preferences for edible legumes must be considered, as described in a study from Malawi by Bezner Kerr et al. (2007). Multi-educational activities and participatory research was carried out with farmers for 5 years. The topics included not only soil building properties and biological consequences of legume residue management but also legume nutritional benefits for different family members. As a result, significantly more households reported feeding more edible legumes to their children compared with control households (Bezner Kerr et al. 2007).

Biofortification of soils

In combination with fertilisers, essential mineral micronutrients that are deficient in a population could be added to the soil, which would not be very expensive. This strategy has been partially successful in certain geographical locations for iodine, selenium and zinc, as they are mobile in the soil but it is questionable how sustainable this approach is in the long term as the micronutrients have to be continuously available and affordable for farmers. There are also questions about application methods, soil composition, and mineral mobility in the plant. Biofortification was not successful for iron, which has a low mobility in soil. In addition, plant growth and soil organisms can be negatively affected by the application of large quantities of metals to the soil. Consequently, this strategy could be relevant for certain crops and specific soils if input is available, but cannot be universally employed as an approach to improve the nutritional quality of foods (Hirschi 2009).

In conclusion, when observing the role that agricultural production can play in contributing to balanced nutrition it must be understood that a multitude of effects exist along the entire food supply chain that add up to a complex model. This model is exemplarily visualised for vegetarian nutrition in Fig. 4. Not all sectors of the food chain are located in the agricultural system. At some point food processing starts and here the responsibility of agriculture for food systems ends. No clear borders exist between the different fields of activities: food production, post harvest and food processing at household, artisanry and/or food industry level. Communication between the stakeholders of the different fields is an important prerequisite to understanding the different roles and responsibilities for producing and processing foods that will ensure sustainable diets.

Food processing

This section will investigate entry points for "nutrition-sensitivity" that occur once the raw food has been produced by agriculture and will include both post-harvest issues and food processing of food. Only if the "nutrition-sensitive" concept is applied along the whole food chain can sustainable and nutritionally adequate diets be achieved. As a country develops, the food systems usually grow increasingly complex; for example evolving from subsistence oriented to market oriented agricultural production. The processing and handling of food can, on the one hand, increase seasonal food availability and the range of food options available to individuals but on the other hand, consuming highly processed foods is, in general, disadvantageous to health owing to their excess

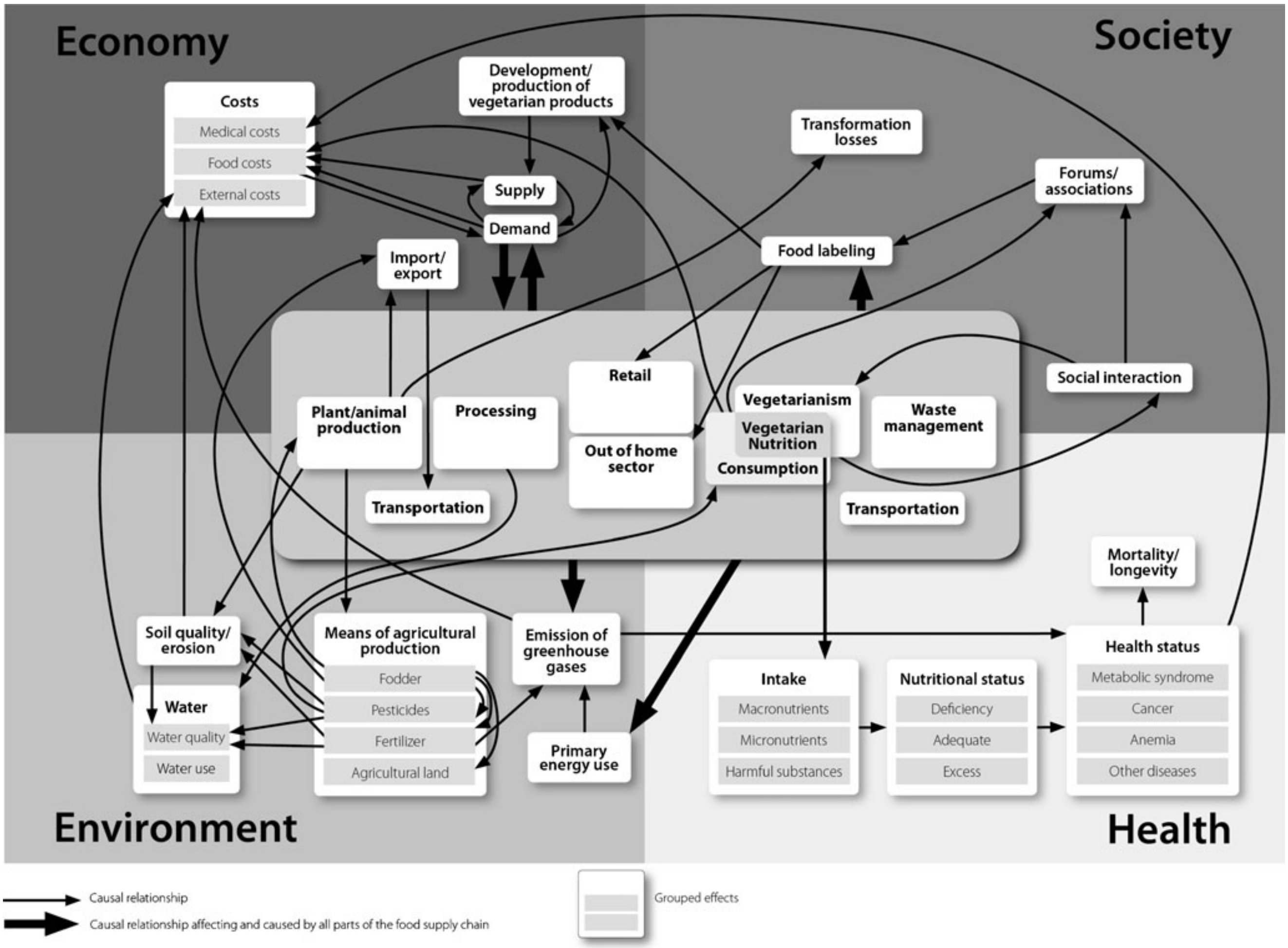

Fig. 4 The vegetarian nutrition model showing a multitude of effects linking economy, society, environment and health (Source: Metz and Hoffmann 2010; Metz and Hoffmann 2009) Hyperlinkmodel: http://www.uni-giessen.de/fbr09/nutr-ecol/forsc_veg.php

energy-density, sugar, salt and unfavourable fat content (Waage et al. 2011).

Post-harvest losses

Physical losses occur when food decays or is infested by pests, fungi or microbes, while handling and processing or because the appearance or shape of the product does not meet quality standards and is rejected. Studies on post-harvest losses have focused so far mainly on grains. For Sub-Saharan Africa these losses are estimated to be $4 billion a year according to the World Bank/FAO (2011) and for physical losses prior to processing between 10 and 20 % according to APHLIS (2012). If economic and nutritional losses are added to these losses it becomes apparent that addressing waste and reducing food losses along the whole food chain must be part of an integrated approach to food and nutrition security.

Estimates of food waste in the UK range from 30 to 50 % of all food grown (IMechE 2013). How much waste occurs at which stage is difficult to measure and is still debated. The UK Foresight Report calculated that about 50 % of UK food waste is in the home (people throwing out of date food away, discarding edible parts of food in preparation etc.), 25 % in the food service industry and 25 % in the food distribution system. Of that total the Foresight report suggests that about two-thirds is avoidable. While this might be true for several developed countries, a much greater percentage of waste may exist in the food production, storage and distribution systems in emerging economies. Drivers of waste include increasing incomes (greater demand for perishables, especially those that are regular in shape), urbanisation and supermarkets (more food purchased and a premium on food appearance), and globalisation (greater distance travelled etc.; Haddad 2013).

Processing of foods at different levels

The assessment of processed food encompasses more than taste, nutrient value and cost. Depending on the processing approach there are a number of aspects, which impact human nutrition along the whole food chain. The evaluation approach described by Riegel et al. (2005; Fig. 5) can be used to rate

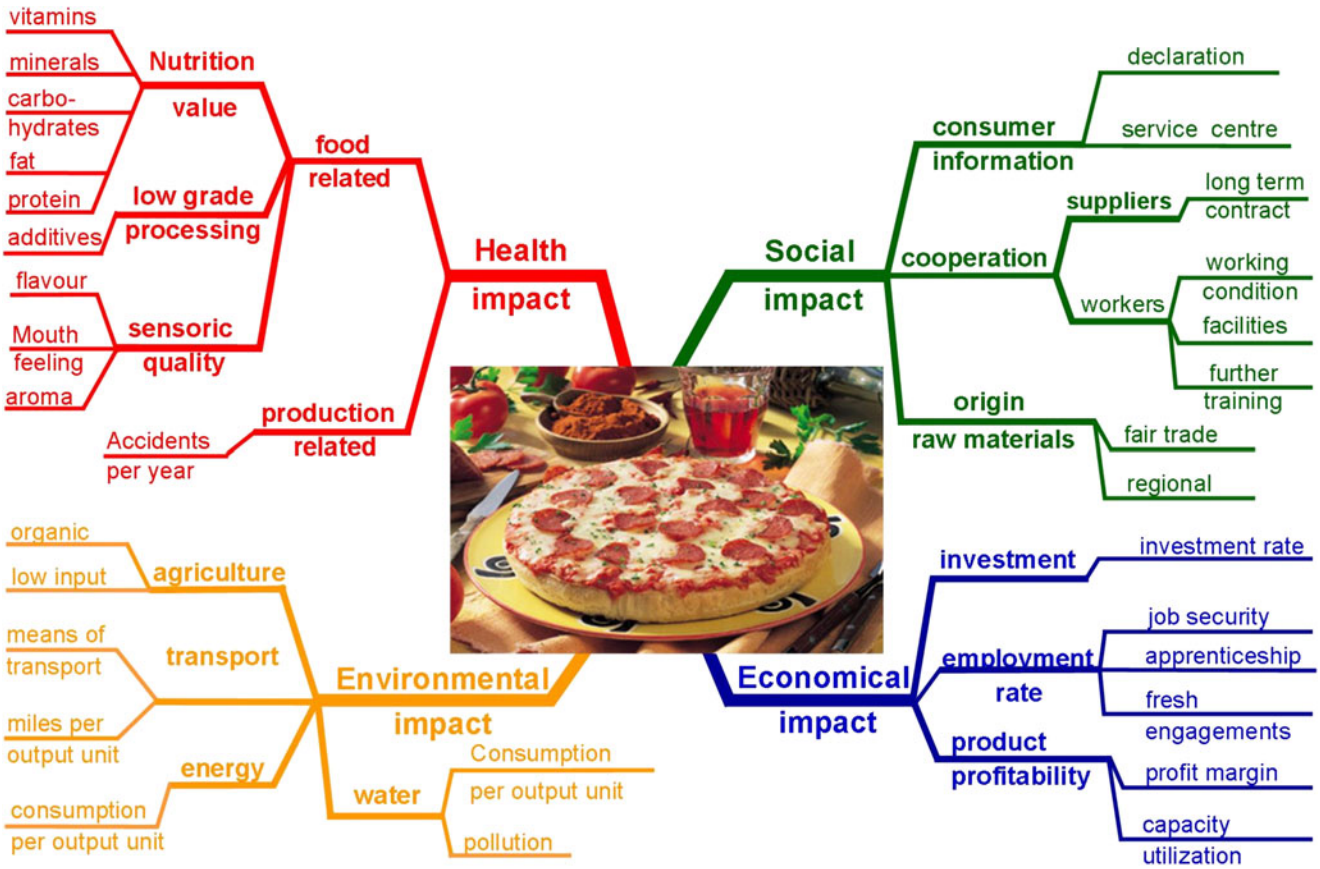

Fig. 5 Nutrition ecological assessment of processed foods (Riegel et al. 2005)

processed food regarding its impact not only on health but also on sustainability.

Processing of foods is very important in order to ensure food security, especially during times when agriculture cannot provide fresh food. At the household level it becomes even more important if the income of the household does not allow the purchasing of food, fresh or processed, needed for the adequate nutrient intake to cover, for example, seasonal gaps or if food storage at the household level is poorly managed.

In general, several challenges complicate the processing approach in developing countries, for example, inability of the food processing industry to process and preserve adequate fresh farm produce to meet demand. Also, seasonality of production means that a processing facility may not be used year-round, which could be an obstacle for investment (Gustavsson et al. 2011).

Regarding the image of processed foods, activists continue to attack processed foods, despite the fact that some foods require processing to be palatable (e.g., grains), safe (e.g., pasteurized milk), or available year round (e.g., canned, dried and frozen fruits and vegetables; Dwyer et al. 2012). A study of consumer knowledge revealed that the mostly negative social, political, and economic attitudes toward processed foods were driven in part by the belief that these foods cause obesity, and, secondarily, by the growing local and organic food movements. The analysis also revealed that benefits of processed foods were not being communicated clearly and consistently and that negative messaging about processed foods was appearing in the marketplace (Dwyer et al. 2012).

Processed foods in developing countries would have, however, a modern image (Becquey et al. 2010). Processing is done at various levels during post-harvesting: in the field at the commercial and village levels and at the household/ domestic level.

Nutrition-sensitive food processing: entry points

Solutions to bridging the gap in availability of certain crops or fresh foods are various and include improved postharvest technologies to ensure that food is not damaged and spoiled easily after harvest. These comprise harvest, transportation and storage technologies and, where appropriate, cooling systems. These technologies would fall under the responsibility of agriculture if raw products are handled. As we move further along the food chain, agriculture becomes less accountable and we enter the field of responsibility of the household, artisanry or food industry (if available). This would include food processing at different levels (factory, village, household, individual) and to different degrees (minimal, culinary, and “ultra-processing”) (Monteiro 2010).

Regarding post-harvest technologies, various solutions are available to reduce food waste, for example, post-harvest grain losses caused by insects; however, most of them are not appropriate for small-scale farmers in developing countries. However, recent innovative solutions for grain storage, using readily available local materials, have been tested and suggest the use of either insecticide-treated bed nets, low-cost and food-safe repellents or creating a modified atmosphere in storage that kills insects by using CO_2 from composting material (Dowell and Dowell 2012). Using insecticide-treated bed nets not for the protection of household members against Malaria but for grain storage could be a negative trade-off. On the other hand, food storage solutions for small-scale farmers are badly needed and especially solutions that are adapted to the local conditions and acceptable and affordable for the target population. While in poorer countries the main solution is to invest in new infrastructure and technology to minimise waste, in richer countries the focus needs to be more on behaviour change in the consumer, better education in schools, setting waste reduction targets in public facilities, or regulating retail promotions that encourage excess purchasing and consumption (Haddad 2013). Thus, in this context, policy makers play an important role.

In discussions about food processing, the level – minimal, culinary or ultra-processing – is often not clear. From the nutrition point of view, minimally processed foods are frequently considered healthier than the ultra-processed foods as defined by Monteiro (2010). According to Monteiro (2010), through "industrial" food processing, unprocessed foods would become either directly suitable for consumption or storage or they would be transformed into foods suitable for "culinary processing", which would mean some further culinary or kitchen processing. To a certain extent this first processing step is and can be done directly at the household level. However, the technology available on the industrial level might reduce post-harvest losses because it can be performed on a larger scale as well as prevent nutrient losses e.g. through controlling heat exposure while processing. Processing does not necessarily mean loss of nutrients but can also have different positive effects on bioavailability (Table 3; Rickman et al. 2007; Burgess et al. 2009).

Figure 6 presents the position of three types of processing in the food system. Type 1 food processing is usually undertaken by the primary producer, packing house, distributor or retailer, as well as by manufacturers, for eventual sale to consumers. Type 2 processing still uses unprocessed foods to extract or 'purify' specific substances, thereby converting them into culinary ingredients, which are used in preparation of unprocessed or minimally processed foods at home or in catering outlets. The third group of food processing combines un- or minimally processed foods with already processed ingredients in order to create so called 'fast' or 'convenience' foods. These ultra-processed products are typically designed to be consumed anywhere and be transportable for long distances, have a long shelf life, and are often habit forming (Monteiro 2010). In the following, specific entry points for food processing at different levels are discussed.

Factory level

Factory food processing and production can transform a society from mainly subsistence farmers to factory labourers (Clarke 2004), which might affect food security of the individual positively as well as negatively. Processing large amounts of foods can be advantageous as it could expand the national economy by sales, possibly even on the world market. However, the community as a whole does not often share the profit, which is the main drawback of shifting towards factory food processing (Clarke 2004). Clarke (2004) demands that "factories need to be well planned and should be not too big as otherwise massive investments may be lost and local lifestyles, cultures and traditions can be seriously and often irretrievably affected". An alternative approach for factory processing might be village processing (Clarke 2004) which will be discussed below.

Factory food processing needs a certain infrastructure to run economically. Next to a constant power supply, the supply chain, a functioning retail market and a transport and marketing

Table 3 Effects of processing on nutrient content of foods (Burgess et al. 2009)

Method	Effect on nutrient content
Drying	Reduces water and so increases the density of other nutrients, reduces vitamins A (less lost if dried in shade) and C
Milling	Fibre, fat, protein and B vitamin losses increase with degree of milling. Can reduce phytates and so improve absorption of iron, zinc and calcium Makes some nutrients easier to digest Soaking before milling reduces phytates and some micronutrients
Sour fermenting	Reduces phytates and increases absorption of iron, zinc and calcium
Germination/ malting	Reduces phytates. Increases vitamin C if not dried
Cooking	Makes starch digestible, can increase availability of beta-carotene, reduces amount of vitamins C and folate; high temperature frying produces trans fatty acids

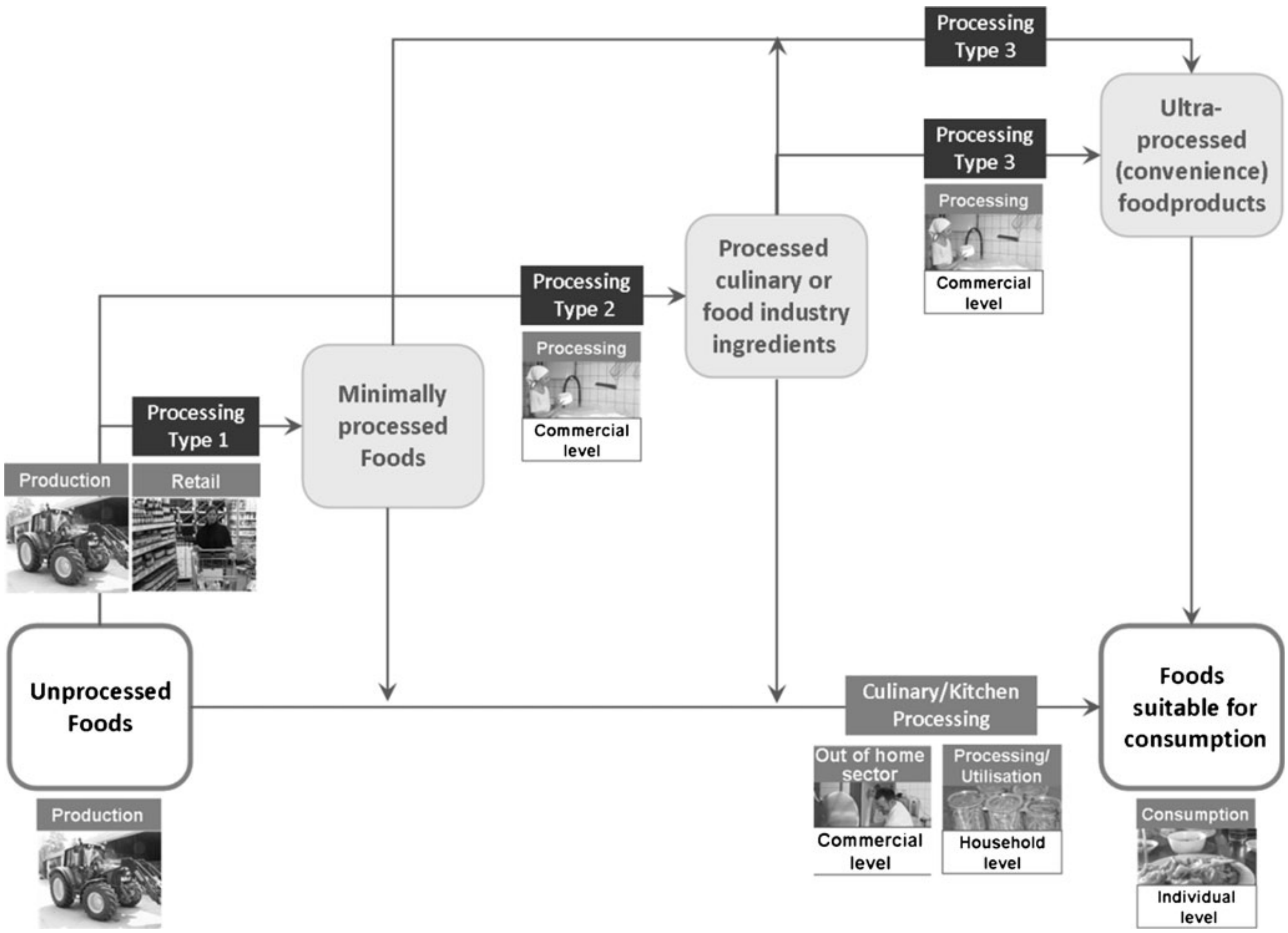

Fig. 6 Three types of food processing within the food system (modified from Monteiro 2010)

system are needed to ensure that the final product reaches the targeted consumers. National and international food safety regulations, e.g. Codex Alimentarius established by FAO and WHO in 1963, as well as functioning food control or public health systems are needed to protect consumers against health hazards such as food poisoning or poor food quality caused by unhygienic production procedures or the factory's interest in profit over-riding safety.

Canning is a very suitable method to extend the shelf life of food and to bridge seasonal as well as infrastructural gaps. Due to very sophisticated technologies, e.g. ensuring that the heat exposure of the food is kept to a minimum, industrial canned food can have the same nutritional value as fresh food or even better (Rickman et al. 2007).

Biotechnology in the food-processing sector makes use of micro-organisms for the preservation of food and the fermentation bioprocess and is the major biotechnological application in the processing of food. Furthermore, food additives and processing aids are currently produced using genetically modified (GM) micro-organisms. The reasons for successes or failures of application of biotechnology in developing countries are mainly of a socio-economic nature. Where the cost of food is a major issue, uptake and adoption of improved biotechnology is generally slow. However, the rate changes with increasing consumer income, education and new market opportunities (FAO 2010b). Acceptance levels may differ markedly among different societies.

Food fortification is either a commercial choice for providing extra nutrients in food (market driven fortification), or is a public health policy which aims to reduce the number of people with dietary deficiencies in a population. The most prominent example of successful food fortification is that of table salt with iodine, through which iodine deficiency disorders have been substantially reduced. Another example of fortifying foods with a single nutrient is the fortification of vegetable oils with vitamin A. Double fortification may be achieved with, for example, iodine and iron in salt. Also multiple-micronutrient mixes are added to some foods, e.g. wheat (Allen et al. 2006; FAO 2003).

Because lack of clarity regarding the level of fortification, bioavailability of the nutrients added, nutrient interactions, stability, characteristics of physical properties and acceptability by consumers (FAO 2003), more knowledge through research is needed. While fortifying foods with micronutrients is a valid strategy as part of a food-based approach, it is not an alternative to the consumption of a variety of available foods constituting a nutritionally adequate diet. Only when necessary food supplies are not available or accessible to provide adequate amounts of certain nutrients and only when the fortified food will be accessible to the targeted population is the fortification approach acceptable. Furthermore, the most needy population group often has restricted access to fortified foods, and it is usually not only one nutrient that is lacking but several which cannot realistically be addressed by fortified foods. Next to nutrient deficiencies in importance are non-communicable diseases, which are becoming a major public health problem in developing countries. The role of diets in preventing these is well understood. However, several substances in foods that can be referred to as "phytochemicals" are helpful in reducing the risk of chronic diseases and, thus, a high variety of foods consumed with emphasis on fruits and vegetables is probably the best approach to reducing the risk of non-communicable diseases (FAO 2003).

Village level

In comparison to the factory level, using machines at village level offers many advantages such as reduced post-harvest losses, food supplies throughout the year, added value to crops before sale and is considered to be an alternative approach to factory processing (Clarke 2004).

Processing at the village level can operate in the form of cooperatives or at the private level: the wealthier farmer lends his machinery to the less wealthy farmers in the village. This method is usually less profit oriented and the farmer maintains his independence. Next to the processing steps at the harvest level there are generally six main categories that are suitable for village scale food processing, namely heating, removing water, removing heat, increasing acidity, using chemicals to prevent enzyme and microbial activity and excluding air, light, moisture, micro-organisms and pests (Fellows 2004). Several processes are usually involved to obtain one processed food, e.g. jam production requires heating, removing water, adding sugar and packaging. Food processing at village level might increase the income and indirectly the food security level of village members. However, the quality, safety and taste as well as nutritional value of the final product, are often challenging but very important for the health of the customers and long run benefit.

Household and individual level

Domestic processing at the household level is limited to small-scale production and can have variable quality. It is suitable for the immediate family with a little extra capacity for local markets or roadside sales. Because domestic processing cannot take advantage of powered machinery, except where an electrical supply is available, it cannot have much influence on the community (Clarke 2004). In industrialized countries many technologies are available at the household level to store and process foods. These technologies are not applicable in the absence of electricity as is the situation in many rural areas of low income countries. Traditional technologies such as the drying of food on the side of roads or in front of the house, however, lead to high losses in quantity and quality (Ibeanu et al. 2010). Agricultural systems need therefore to collaborate with manufacturers and food scientists to improve access to appropriate technologies for locally grown foods (Hotz and Gibson 2007).

In the course of food security programmes, additional crops, unknown to communities, might be introduced to farmers in order to improve nutrition. Here it is very important to provide training on the use of these crops to ensure that they will be used appropriately in the targeted households. However, there are limitations if an additional workload, which may have a negative effect on the caring capacity of household members, is involved. Initiatives such as the commercial processing of bitter cassava to Gari, which is very time consuming, are therefore very important (Nkamleu et al. 2009; FAO 1984, 1990).

Technology used to reduce food losses at the household level is crucial and might even be necessary to make food palatable as it is in the case of bitter cassava or to increase the bioavailability of micronutrients, for example, through fermentation. Many methods are available; some are more time consuming than others. However, women are often responsible for food processing and preservation as well as many other chores and the burden is especially high during the harvest season. A sophisticated cropping schedule, including diversification of farm crops in order to distribute planting and harvesting more evenly across the year, could ease women's agricultural workload, which has been identified as an important barrier to improving nutritional behaviour in the Bolivian Andes (Jones et al. 2012). This is especially important when preservation of food is needed directly after harvest but cannot be done due to too much work required for the actual harvesting. Particular attention must be given to women's workload to ensure that women, who are also responsible for the care of children and family nutrition in general, are not overburdened by the introduction of new tasks or labour intensive technologies (FAO 2013b).

Approximately 5 % (1.7 million) of deaths through non-communicable diseases (NCDs) worldwide are attributable to low fruit and vegetable consumption alone each year (WHO 2013) and approximately 2.5 million children die every year from childhood malnutrition (FAO 2012b). These figures demonstrate the inadequacy of the contemporary food system and must be brought down. In 1999 Lang listed various areas of tension in the current food system such as globalization versus localization, intensification versus extensification, monoculture versus biodiversity, food from factories versus food from the land, people to food versus food to people, fast food versus slow food. As he pointed out, "the challenge [of] how to balance seemingly contrary policy imperatives – health, environment, consumer aspirations, commerce – and how to bridge tensions within the food system – land, industry, retailers, catering, domestic life – is formidable". It is still unresolved and requires a paradigm shift (Lang 1999 and 2009). A revision of the food system is essential to achieve culturally acceptable, sustainable and healthy food systems and thus, sustainable diets for all. Simply changing the food system to a more nutrition sensitive one within environmental limits will not be sustainable if it is not developed with fairness and justice and in consideration of the different stakeholders in a broad interdisciplinary approach (Garnett 2013).

Education and knowledge

As discussed already by Jaenicke and Virchow (2013) two of the entry points for fostering nutrition-sensitive agriculture are awareness creation and capacity building. Next to the disconnect of University departments of agriculture, nutrition and medicine (or other educational institutions) are the traditional separation among the ministries of these three subject areas. "Ministerial structures and bureaucratic routines in governments are traditionally segregated by sector and resistant to anything more than incremental change" (Paarlberg 2012).

However, all three sectors – agriculture, nutrition and health – need to harmonise (UNICEF 1990). For example, stakeholders in the agricultural sector need to be aware of what is needed for a healthy and balanced diet before agriculture can become nutrition-sensitive. Intersectoral communication and action seem to be keys if nutrition security is the overall goal.

However, a number of gaps in agriculture concerning nutrition research have been identified by Hawkes et al. (2012). These are:

- "A lack of research extending through the whole chain, the link with food environment indicators, through to measurements of individual food intake or dietary diversity, infant and young child feeding practices, and nutritional status. This gap prevents a more complete understanding of the full pathway of change."
- "A lack of research on the indirect effect of changes in agriculture on nutrition, acting through agricultural effects on income and economic growth and associated changes in health and investments in health and education services."
- "A lack of research on the effects of agricultural policy change on nutrition through the value chain. Given the potential of policy to have broad and extensive impacts at a population level, this is an extensive gap."
- "A gap in research on broader target groups, notably consumers more broadly such as rural wage workers and non-rural populations – a consequence of which is a profound gap in research on the potential for agriculture and food value chains to improve the diets of the rural and urban poor at risk from nutrition-related NCDs."

Regarding research, multidisciplinarity with all subjects working in parallel needs to be replaced by inter- or transdisciplinarity. Interdisciplinarity means that two or more academic disciplines, e.g. agricultural sciences, nutritional sciences and medicine, cooperate by crossing boundaries and thinking across them, thereby creating a joint perspective for an integrated result, e.g. ways to implement sustainable diets. (Defila et al. 2006) Transdisciplinarity goes beyond this approach and combines interdisciplinary cooperation with participation of non-scientific players to solve so called real-world problems (Defila et al. 2006; Klein et al. 2001; Kötter and Balsiger 1999). For nutrition-sensitive agriculture this approach would mean integrating not only of the different disciplines in research but also of farmers, consumers, suppliers, retailers, processors, consultants and policy makers, i.e. all stakeholders along and around the food chain (IAASTD 2008 and Fig. 7).

Awareness creation through nutrition education, including hygiene and health topics, needs to go hand in hand with agricultural production. Nutrition education at the household level needs to work with the foods available during different seasons, while agriculture extension services need to include nutrition education among food producers to ensure that the necessary foods are produced.

Education has meanwhile been recognized as an important factor for the prevention of malnutrition (Smith 2003). However, the requirement for education can be reduced by improving agricultural and health systems, as a case from Laos shows (Kaufmann 2009). Further examples include:

- Education is necessary not only about agricultural practices (e.g. soil building properties and biological consequences of legume residue management) but, at the same time, about nutritional benefits (e.g. of legumes) for different family members (see part 3 "Soil fertility");
- The benefits of processed foods need to be communicated clearly to ensure their acceptance and to counter negative attitudes. (see "Processing of foods at different levels");
- Capacity building and knowledge expansion for the promotion and application of processing at the village and especially at the household level (see "Household and individual level").

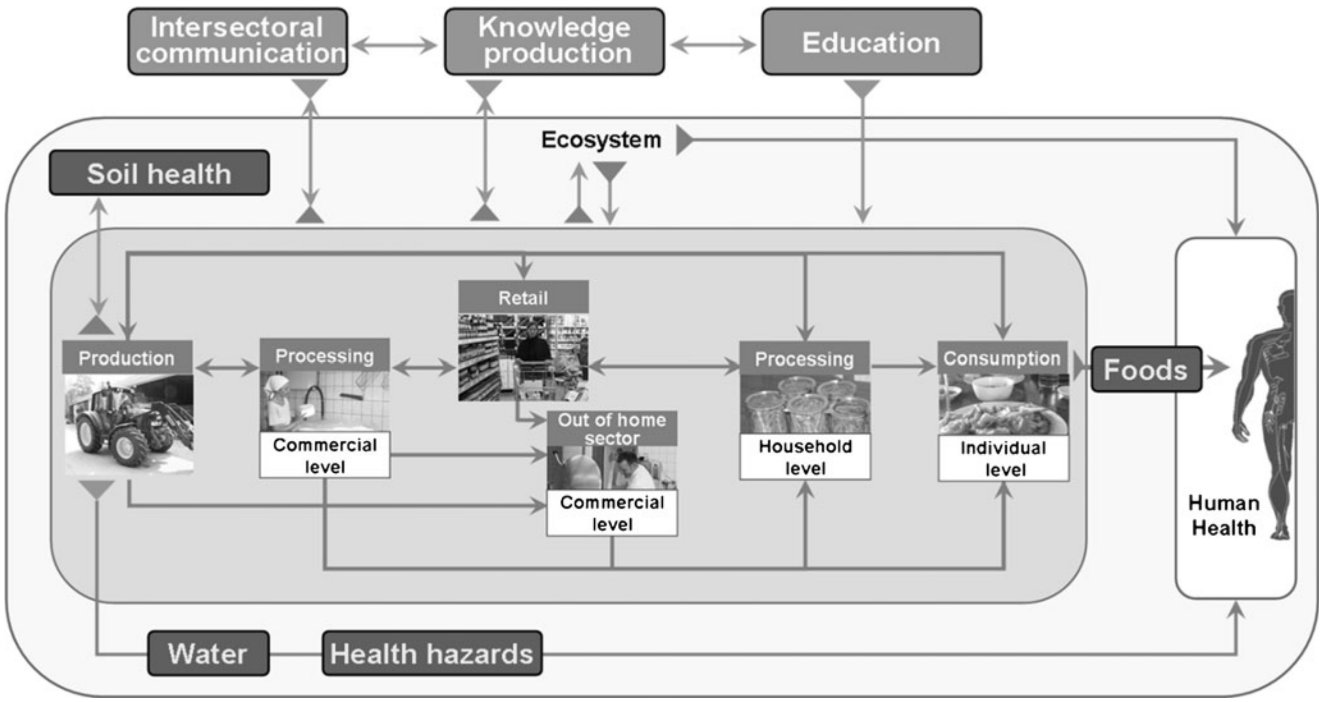

Fig. 7 The food chain and recommended entry points for promotion of nutrition-sensitive agriculture (modified from Schneider and Hoffmann 2011a, b)

A systems approach may be of particular value in understanding and shaping food and nutrition security (Hammond and Dube 2012) and thus, nutrition-sensitive agriculture. Both researchers and policy makers would benefit from such an approach which, according to Hammond and Dube (2012), would connect interrelated systems across disciplinary lines, and explicitly examine interaction effects and feedback.

Conclusion

The conceptual framework of malnutrition presented by Jonsson (1981) and UNICEF (1990) explains why there is the need to link agriculture and health. However, agricultural and health sectors are largely disconnected in their priorities and policy objectives. Typically, agricultural priorities centre on production and processing systems, markets, and livelihoods, with concern for food safety only as it affects trade, rather than broad public health issues. By contrast, public health traditionally centres on agriculture insofar as it affects food security and food safety, with only recent consideration of agriculture's potential role in prevention of non-communicable diseases. Neither sector is fully responsible for the complex inter-relationships between and among agri-trade, food consumption patterns, health, and development. (Lock et al. 2010)

Agriculture can already be nutrition-sensitive when, for example, pursuing the importance of fruit and vegetable production and tackling all potential challenges of these highly perishable products along the food chain. While from the nutrition side the consumption of, e.g. five portions of a variety of fruits and vegetables each day ("5 a Day" programme) is encouraged and promoted (WHO, FAO 2003; 5 am Tag e.V 2012), farmers need incentives and all prerequisites to provide sufficient quantities of these that are accessible during all seasons as well as being culturally acceptable and affordable by everyone, especially those in need. In addition, the sustainability of fruit, vegetable and general food production, considering environmental factors, is fundamental to sustainable diets. Food processing is a crucial interface between producers and consumers. Science and politics are absolutely required to fully exploit the potential of processing at the industrial, village and household level.

Education of farmers and support of their existing knowledge about agricultural production systems, which conserve the environment and provide adequate food for all, is an essential and integral part of nutrition-sensitive agriculture. Also, for nutrition-sensitive agriculture to be successful, consumers must be educated so that they understand what healthy foods and diets are (Monteiro 2010; IAASTD 2008). Consequently, the topic should be termed "nutrition-sensitive food systems" and should include agricultural production, food processing and, in particular, health and sustainability.

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Glossary

Dietary Diversity Score	Dietary diversity is a qualitative measure of food consumption that reflects household access to a variety of foods, and is also a proxy for nutrient adequacy of the diet of individuals. The dietary diversity scores described in the FAO guidelines consist of a simple count of food groups that a household or an individual has consumed over the preceding 24 h (FAO 2011).
Food fortification	As stated in the FAO/WHO guidelines on food fortification with micronutrients "food fortification is usually regarded as the deliberate addition of one or more micronutrients to particular foods, so as to increase the intake of these micronutrient(s) in order to correct or prevent a demonstrated deficiency and provide a health benefit" (Allen et al. 2006).
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 1998). This definition was supplemented by adding the following: The four pillars of food security are availability, access, utilization and stability which are integral to the concept of food security [CFS: 2009/2 Rev. 2] (FAO 2012c).
Global Hunger Index	The Global Hunger Index (GHI) is a tool designed to comprehensively measure and track hunger globally and by region and country. Calculated each year by the International Food Policy Research Institute (IFPRI), the GHI highlights successes and failures in hunger reduction and provides insights into the drivers of hunger. To reflect the multidimensional nature of hunger, the GHI combines three equally weighted indicators in one index: • Undernourishment: the proportion of undernourished people as a percentage of the population (reflecting the share of the population with insufficient caloric intake) • Child underweight: the proportion of children younger than age five who are underweight (that is, have low weight for their age, reflecting wasting, stunted growth, or both), which is one indicator of child undernutrition • Child mortality: the mortality rate of children younger than age five (partially reflecting the fatal synergy of inadequate caloric intake and unhealthy environments) (IFPRI 2012).
Hidden Hunger	Micronutrient malnutrition or vitamin and mineral deficiencies, which can compromise growth, immune function, cognitive development, and reproductive and work capacity. (World Bank 2013)
Nutritional functional diversity	The nutritional functional diversity metric is based on plant species composition on farm and the nutritional composition of these plants for 17 nutrients that are key in human diets and for which reliable plant composition data are available. This metric can be used to summarize and compare the diversity of nutrients provided by farms. The nutritional functional diversity value increases when a species with a unique combination of nutrients is added to a community and decreases when such a species is lost (Remans et al. 2011).
Nutritional Status	The nutritional status of a person can be measured by different methods, such as anthropometry, biochemical and clinical assessment, and dietary intake methods. Anthropometry is the method commonly used. It can be defined as the measurement of physical dimensions and gross composition of the human body. The nutritional status of a person alone does not indicate the causes of this status (FAO 2012c).
Nutrition Security	As the term "food security" evolved, the term "nutrition security" emerged in the mid-1990s. Nutrition security focuses on food consumption by the household or the individual and on how that food is utilized by the body. Building on UNICEF's Conceptual Framework, IFPRI proposed the following definition in 1995: "Nutrition security can be defined as adequate nutritional status in terms of protein, energy, vitamins, and minerals for all household members at all times".

	In 2006, the World Bank published a book on Repositioning Nutrition as Central to Development. It gives the following more elaborate definition of nutrition security: "Nutrition security exists when food security is combined with a sanitary environment, adequate health services, and proper care and feeding practices to ensure a healthy life for all household members." This same definition of nutrition security is also used by WHO in its forthcoming report of the Global Nutrition Policy. In an effort to focus attention on the point that nutrition security is only achieved when individuals actually consume the food they need rather than simply having access to it (as in the currently accepted definition of food security), FAO has developed the following draft formulation: "Nutrition security exists when all people at all times consume food of sufficient quantity and quality in terms of variety, diversity, nutrient content and safety to meet their dietary needs and food preferences for an active and healthy life, coupled with a sanitary environment, adequate health, education and care" (FAO 2012c).
Recommended Dietary Allowance	Recommended dietary allowance refers to the intake level that meets the daily nutrient requirements of almost all (97 to 98 %) of the individuals in a specific life-stage and sex group (Gibson 2005).
Triple burden of malnutrition	The triple burden of malnutrition consists of 1) insufficient intake of dietary energy and protein resulting in hunger, reduced learning ability, diseases and premature death, 2) micronutrient deficiencies causing physical and cognitive deficits, anemia, blindness and reduced resistance to a variety of health risks, and 3) excess intake of dietary energy resulting in overweight, obesity and chronic diseases. It continues to be a very serious set of global public health problems and an important contributor to slow economic growth, widespread poverty and high rates of morbidity and mortality in most developing countries (Herforth et al. 2012).

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