

Applying a Transdisciplinary Mixed Methods Research Design to Explore Sustainable Diets in Rural South Africa

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Abstract

This article describes a conceptual framework for exploring sustainable diets, using a case study example of ongoing research in the Vaalharts region, a rural setting in South Africa. A qualitative research approach is followed with an integrated transdisciplinary mixed methods research design with multiple concurrent components employed during two sequential phases. A successful application of the framework is achieved through a collaborative team effort of researchers with qualitative and quantitative research expertise transcending different disciplines, as well as participation of community members throughout the research process. We demonstrate that transdisciplinary mixed methods research designs are essential to gain a better understanding of the complex concept of sustainable diets.

Keywords: sustainable diets, mixed methods, case study, transdisciplinary research, South Africa

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The concept of sustainable diets as defined by the Food and Agriculture Organization (FAO) & Bioversity International considers:

[...] diets with low environmental impact which contribute to food and nutrition security and to a healthy life for present and future generations. Sustainable diets are protective and respectful of biodiversity and the eco-system, culturally acceptable, accessible, economically fair and affordable, nutritionally adequate, safe and healthy; while optimizing natural and rural resources. (Burlingame & Dernini, 2012, p. 7)

Gussow and Clancy (1986) already stressed the interdependencies among food choices, human health, and natural resources. However, it is only in recent years that the concept of sustainable diets has received renewed attention in response to rising global imbalances in nutritional, social, and economic well-being, as well as rapid environmental degradation that has included loss of food biodiversity and increased dependence on only a few food species for the bulk of the world's food supply (Burlingame & Dernini, 2012). Increasing rates of overweight and obesity worldwide are adding to these negative outcomes (Ng et al., 2014).

Given the complexity, sustainable diets research, therefore, must transcend different disciplines, such as nutrition, agriculture, economics, and behavioral, environmental and social sciences. Researchers of several large-scale national and transnational studies, such as Foresight (2011), MacDiarmid et al. (2011), and Nugent (2011) have applied transdisciplinary approaches to assess the contribution of current food systems to the rising levels of obesity and diet-related non-communicable diseases (NCDs), and their impact on the environment. These studies have substantially contributed to a better understanding of sustainable diets and emphasize the need for change of the current globalized agro-food system to counteract the rise of NCDs and increasing environmental degradation. These studies further pointed to the need for a better understanding of the drivers and inhibitors to achieving more sustainable food production and consumption (Foresight, 2011; MacDiarmid et al., 2011; Nugent, 2011). Johnston, Fanzo, and Cogill (2014) further reiterated the urgent need for a deeper understanding and new creative ways that incorporate quantitative *and* qualitative research approaches to measure and assess the complexity of sustainable diets. What is needed, therefore, is transcending boundaries not only among disciplines but also between the qualitative and quantitative research paradigms, to more comprehensively and meaningfully contribute to evidence generation on sustainable diets.

Qualitative research “[...] is an approach for exploring and understanding the meaning individuals or groups ascribe to a social or human problem” (Creswell, 2014, p. 4) and can play a crucial role when exploring factors such as socio-cultural and socio-economic perspectives that describe perceptions, attitudes, or behaviors of consumers and other food chain actors at local levels. Using mixed methods research can further broaden these insights by combining qualitative and quantitative research approaches during data collection, analysis, integration of findings, and drawing of conclusions (Tashakkori & Creswell, 2007). Mixed methods research “[...] actively invites us to participate in dialogue about multiple ways of seeing and hearing, multiple ways of making sense of the social world, and multiple standpoints on what is important and to be valued and cherished” (Greene, 2007, p. 20). Given the wide spectrum of factors that influence the concept of sustainable diets, transdisciplinary and mixed methods inquiry can support better the investigation of the whole spectrum of factors involved. However, there is limited evidence-based research that applies a transdisciplinary and mixed methods research approach in the field of sustainable diets.

In ongoing research, we are exploring the sustainability of diets in rural resource-poor settings within South Africa's largest irrigation scheme located in the Vaalharts region. In this article, we present a transdisciplinary research framework that enables researchers to address the complexity of sustainable diets. First, we describe the conceptual framework with six dimensions that we regard as being most relevant to the South African context, adapted from Johnston et al. (2014); Lairon (2012); Lang (2012); and Lemke (2005). Then, we illustrate and discuss the methodological application of this framework in this case study research that explores sustainable diets via a specific rural area of South Africa.

Conceptual Framework for Exploring Sustainable Diets in Rural South Africa

The most common dimensions included by various authors into sustainable diets concepts relate to health, environment, socio-cultural aspects, economy, and agriculture and food systems. Table 1 provides an overview of the different dimensions that various authors have ascribed to the sustainable diets concept (Johnston et al., 2014; Lairon, 2012; Lang, 2012). Also, we include the dimensions that have been integrated in the conceptual framework presented in this article (Figure 1). Based on these literature-driven dimensions (Table 1), the conceptual framework was developed with six key dimensions and multiple indicators that were identified as being relevant to the given South African context: (a) food security and nutrition, (b) local food structures and flows, (c) environmental sustainability, (d) socio-cultural aspects, (e) economic efficiency, and (f) policy framework and local implementations. Although not specifically reflected within our framework, the dimensions of health, equity, and quality, proposed by other authors (Table 1), are addressed in context to the South African setting within the six selected dimensions of our framework. Specifically, the health dimension is considered in the food security and nutrition dimension because micronutrient deficiencies, overweight, and obesity are major contributors to the burden of non-communicable diseases in South Africa (Puoane et al., 2012). Further, the equity dimension is addressed within the policy framework dimension because a number of significant programs, policies, and regulations are in place that target vulnerable population groups in South Africa (Koch, 2011). Lastly, the issue of quality is addressed within the socio-cultural dimension that includes perceptions of consumers regarding food quality.

Table 1

*Dimensions of Sustainable Diets as Applied by Different Authors and how they relate to the Framework reported on**

Dimensions	Lang, 2012 [#]	Lairon, 2012	Johnston et al., 2014	Framework presented here
Health	x	x	x	
Environment	x	x	x	x
Socio-cultural aspects	x	x	x	x
Economy	x		x	x
Agriculture & food systems		x	x	x
Food and nutrition security		x		x
Governance	x			x
Equity		x		
Quality	x			

* For more details on specific indicators used within each dimension by different authors, the reader is referred to the references provided in this table.

[#] Lang (2012) bases his dimension on the report of the Sustainable Development Commission (2011, p. 14).

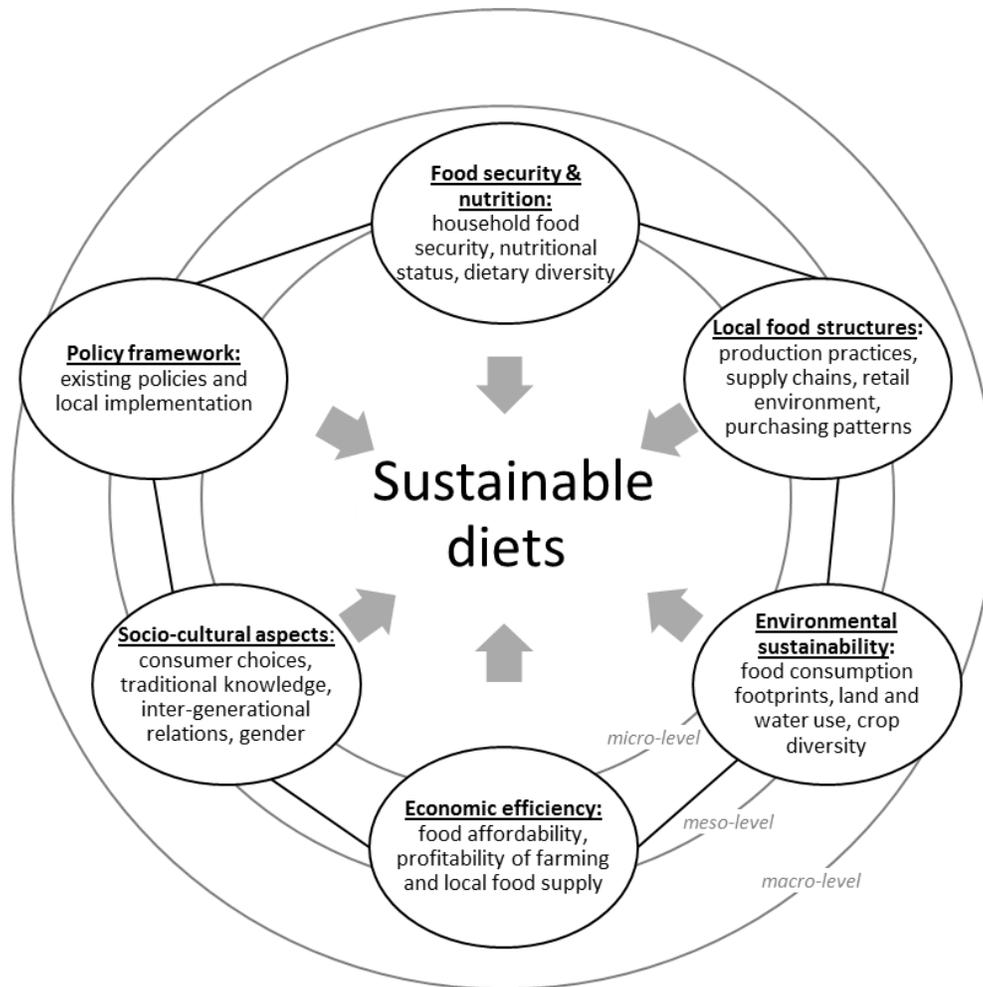


Figure 1. Research framework for exploring sustainable diets in South Africa (adapted from Johnston et al., 2014; Lairon, 2012; Lang, 2012; Lemke, 2005).

All six dimensions of our framework are interdependent and connected, and placed on three circles that represent each dimension's socio-organizational relevance to the micro- (individual and household), meso- (community), and macro- (national) level (Figure 1). This framework draws on a previous framework developed by Lemke (2005) that was applied to assess underlying causes of nutrition insecurity among South African farm workers. In the following sections each research dimension is described briefly with respect to the South African context.

Food Security and Nutrition

According to the country study of the United Nations System Standing Committee on Nutrition (2013), South Africa is considered food secure with national food production levels adequate to meet local consumption requirements of the population. Yet, large numbers of households within the country face food insecurity, lacking adequate physical, social, or economic access to food. The latest South African National Health and Nutrition Examination Survey (Shisana et al., 2013) revealed that 28% of the population are at risk of hunger and 26% experience hunger (are food insecure), with high prevalence in rural localities. Children are most vulnerable with regard to undernutrition, with 26% of children, 1-3 year old, being stunted (i.e., of low height for age compared to a standard population as an indicator of chronic malnutrition [Victora et al., 2008]). At the same time, obesity levels are increasing, especially among women (39% of women aged 15 and older), reflecting the co-existence of under and overnutrition in South Africa (Shisana et al., 2013).

Aspects to address the household food security and nutrition dimension in our case study include: household food security, nutritional status of different household members, dietary diversity with regard to types of food accessed by households, and quality of the diet at the individual level. In turn, what households are able to access will provide insights into food value chain dynamics in the given setting.

Local Food Structures

Among others, distributional food system challenges contribute to household food insecurity, and result in higher food prices in rural areas where food is actually primarily produced (National Agricultural Marketing Council, 2008). Local food structures and flows refer to the production, processing, distribution, access, and consumption of foods at a local or regional level. Local food systems might, therefore, be a crucial entry point to addressing some of the detrimental effects of global food crises and multinational industrial-dominated food systems. In South Africa, experts call for a localization of food systems to promote the government's envisaged priority to promote rural development and food security (De Schutter, 2011; Ortmann & King, 2010). While commercial farmers in South Africa struggle to compete in the current competitive economic environment, small-scale farmers face further multiple challenges with regard to a lack of inputs, support structures and training, an inadequate land tenure system, ineffective selection of beneficiaries for government intervention programs, low land potential, and a lack of access to competitive markets (Jacobs, 2003; Ortmann & Machethe, 2003). The position of emerging small-scale farmers has specifically received attention via various government programs. Examples include the Land Redistribution for Agricultural Development Programme (Ministry of Agriculture and Land Affairs, 2001), the Comprehensive Agricultural Support Programme (National Department of Agriculture, 2004), and the Comprehensive Rural Development Programme (Ministry of Rural Development and Land Reform, 2009). Aspects addressed in researching the local food structures dimension in our case study are: production practices, the food retail environment, and determinants of consumers purchasing patterns.

Environmental Sustainability

Adverse environmental impacts of agriculture include direct and indirect effects at various scales. Sources of direct negative environmental impact include inputs such as fertilizer, herbicides, and pesticides that contribute to polluting both surface and ground water, and emission of greenhouse gases, particularly methane through cattle farming. Indirect impacts include disturbances of water, nutrient, and carbon cycles (i.e., carbon sequestration) caused by changes in land use and land cover, following intensive agricultural production that reduces biodiversity and affects natural habitats in various ways (African Biosafety Network of Expertise, 2014; European Environment Agency, 2014). In response, international and local initiatives are being implemented to promote more sustainable agricultural systems, such as the Strategy for Sustainable Crop Production Intensification of FAO (2014).

Aspects for researching the environmental sustainability dimension in our case study include: food consumption carbon footprints, land and water use, and crop diversity. These aspects were chosen, firstly because data obtained within other dimensions enabled secondary data analysis (i.e., calculation of food consumption carbon footprints). Secondly, they focus on the activities that cause adverse environmental impact, thereby threatening environmental sustainability in the quest for food security.

Economic Efficiency

Sustainable diets need to be economically efficient for all food system actors by minimizing input and maximizing output without negative consequences to health or the environment (Burlingame & Dernini, 2012). The desired efficiency is not always evident for small-scale producers in South Africa. On the other hand, as part of the sustainable diets concept, consumers must be able to afford the foods made available by the local food system. Food insecurity in South Africa is largely determined by inadequate economic access to available foods (Altman, Hart, & Jacobs, 2009). Specific aspects chosen for researching this dimension include: affordability of food, profitability of farming, and efficiency of the local food supply system.

Socio-Cultural

In Sub-Saharan Africa, colonial economies and post-independence development schemes promoted the commercial production and consumption of cash crops, such as maize, wheat, and rice. Subsequently, the cultivation of indigenous crops and the gathering of wild species have declined, resulting in the simplification of African diets, described by shrinking food supplies and limited food diversity (Frison, Smith, Cherfas, Eyzaguirre, & Johns, 2005). Dietary consumption patterns of the general South African population largely are based on cereals with little variety, neglecting particularly legumes, vegetables, and fruits (Labadarios, Steyn, & Nel, 2011). Nutrition research in South Africa has clearly demonstrated a nutrition transition towards reduced dietary fibers and increased consumption of refined carbohydrates and fats (Vorster, Kruger, & Margetts, 2011). The observed shift in dietary patterns has resulted in a limited number of domesticated plants providing the bulk for the food and a gradual decline in knowledge about and consumption of traditional foods (Frison et al., 2005). Therefore, socio-cultural perceptions of foods and diets become important considerations to promote more sustainable diets (Burlingame & Dernini, 2012). Specific issues identified in the socio-cultural dimension with importance for investigating sustainable diets in this case study are: drivers of consumer choices, traditional food knowledge and usage, gender issues, and intergenerational interactions.

Policy Framework

The right of access to sufficient food is enshrined in the Constitution of the Republic of South Africa (1996). A number of policies, legislations, and other measures are in place to address the right to food and are therefore, relevant to the sustainable diets concept. For example, the National Development Plan of 2011 (National Planning Commission, 2011) emphasizes expanded use of irrigation, security of land tenure, promotion of nutrition education, job creation, improvement of infrastructure, and an inclusive and integrated rural community. Another example is the food and nutrition-specific policy framework that includes the 2013 National Food and Nutrition Policy (Department of Social Development & Department of Agriculture, Forestry and Fisheries, 2013) and the 2002 Integrated Food Security Strategy for South Africa (National Department of Agriculture, 2002). The National Food and Nutrition Policy provides indicators of food and nutrition security including those at the household level. The utilization of food (specifically the focus on dietary diversity and food preservation) as well as the importance of improved nutrition education are addressed, as is the alignment of agricultural investments towards local economic development (Department of Social Development & Department of Agriculture, Forestry and Fisheries, 2013). In addition to the policies described here, South Africa is unique on the African continent for providing several social cash transfers targeting vulnerable population groups such as child, foster care, disability, and old age grants, as well as provision of housing (South Africa Government Services, 2013). The policy environment in South Africa is relatively supportive to vulnerable groups, although long-term sustainability is increasingly coming into question.

The right to a healthy environment, and duty of the state to uphold that right, is enshrined in the Constitution and addressed through environmental legislation under the framework of the National Environmental Management Act (Department of Environmental Affairs, 1998). The importance of agricultural impact on the environment is recognized and addressed through the mandatory requirement to conduct Environmental Impact Assessment for a wide range of agricultural activities prior to commencement (Department of Environmental Affairs, 2014).

The policy and legislative environment in South Africa, therefore, is favorable to and supportive of sustainable diets in the country. The local level implementation of the given policies might, however, not be adequate. In the context of this case study, the local implementation of existing policies and programs is assessed as being relevant.

Application of the Conceptual Framework: Addressing the Complexities of Sustainable Diets in the Vaalharts Region

Since 2012, the conceptual framework (Figure 1) has been applied to ongoing research that explores the sustainability of diets in the Vaalharts region of South Africa. The aim of this case study is to reveal the

complex interplay of household food and nutrition security with the local food system in this setting, taking into account environmental, political, socio-cultural, and economic determinants; and involving actors along the food chain, such as food producers, processors, retailers, and consumers.

The Vaalharts region, situated between the Harts River in the north-west and the Vaal River in the south, encompasses the largest irrigation scheme in South Africa. Construction begun in 1934 with the intention of alleviating increasing poverty among the White population by providing farming plots to lease. It included provision of free basic housing and farming inputs with the opportunity to purchase the plot after a 4-year probation period. Today, the scheme irrigates a total of 39,820 hectares of licensed land, supporting 1,040 irrigation farmers (approximately 47% established commercial and 53% emerging farmers) (Vaalharts Water, 2014; Van Vuuren, 2010). The scheme comprises a mix of intensive crop production systems involving peanuts, pecan nuts, maize, barley, oranges, cotton, olives, wheat, and vegetables. The central area of the irrigation scheme (Phokwane municipality) has a population of approximately 60,505 (IHS Global Insight, 2015). Despite the high levels of local agricultural output, the population is characterized by relatively widespread poverty and unemployment. In 2013, approximately 38% of the population lived below the lower-bound poverty line, as described in 2011 by Statistics South Africa (2014) as below ZAR R443.00 (USD \$63.84) and the unemployment rate was approximately 41% (IHS Global Insight, 2015). This paradox of highly intensive local agricultural production coupled with severe socio-economic challenges makes the region a useful case study for this mixed methods investigation on different dimensions of sustainable diets.

Trans-Disciplinary Case Study Design

A transdisciplinary research approach that encourages the fusion of knowledge as well as methodologies of different disciplines is essential to investigate the interrelated complexity of sustainable diets. We chose an embedded single case study design with multiple research components (Yin, 2014) to explore the sustainability of diets in the Vaalharts region, a geographically defined area of approximately 220 km radius.

The notation that best describes our research design (Creswell & Plano Clark, 2011) is as follows:

$$\text{QUAL}([\text{QUAL}+\text{QUAN}]^{\text{micro+meso}} \rightarrow [\text{QUAL}+\text{QUAN}]^{\text{meso+macro}})$$

This notation describes that we are using an overall qualitative research approach embedding two sequentially aligned phases that consists of concurrently applied qualitative and quantitative research components. Phase 1 focuses on the micro and meso-level and informs Phase 2, which focuses on the meso and macro-level. The overall qualitative inquiry allows flexibility for adapting methodologies during the research process necessary to respond to and to enable further exploration of emerging themes.

Distinct features of our research design are illustrated in Figure 2. Regular team discussions ensure reflection on data collection, analysis, and interpretation. Experts from various disciplines form the research team, including nutrition, agricultural economics, environmental science, law, consumer sciences, social sciences in agriculture, and social anthropology. The research team further includes two persons who live and work in the communities of the Vaalharts region, adding valuable local contextual knowledge for reflection. The team leader is a nutritionist experienced with qualitative and quantitative research inquiries. In addition, feedback to research participants forms an integral part of the analytical process so that their voices are embedded into data analysis and interpretation processes. This allows for more in-depth contextual reflection and interpretation, important to understanding the complex dimensions of sustainable diets that are mostly missing in standard study designs.

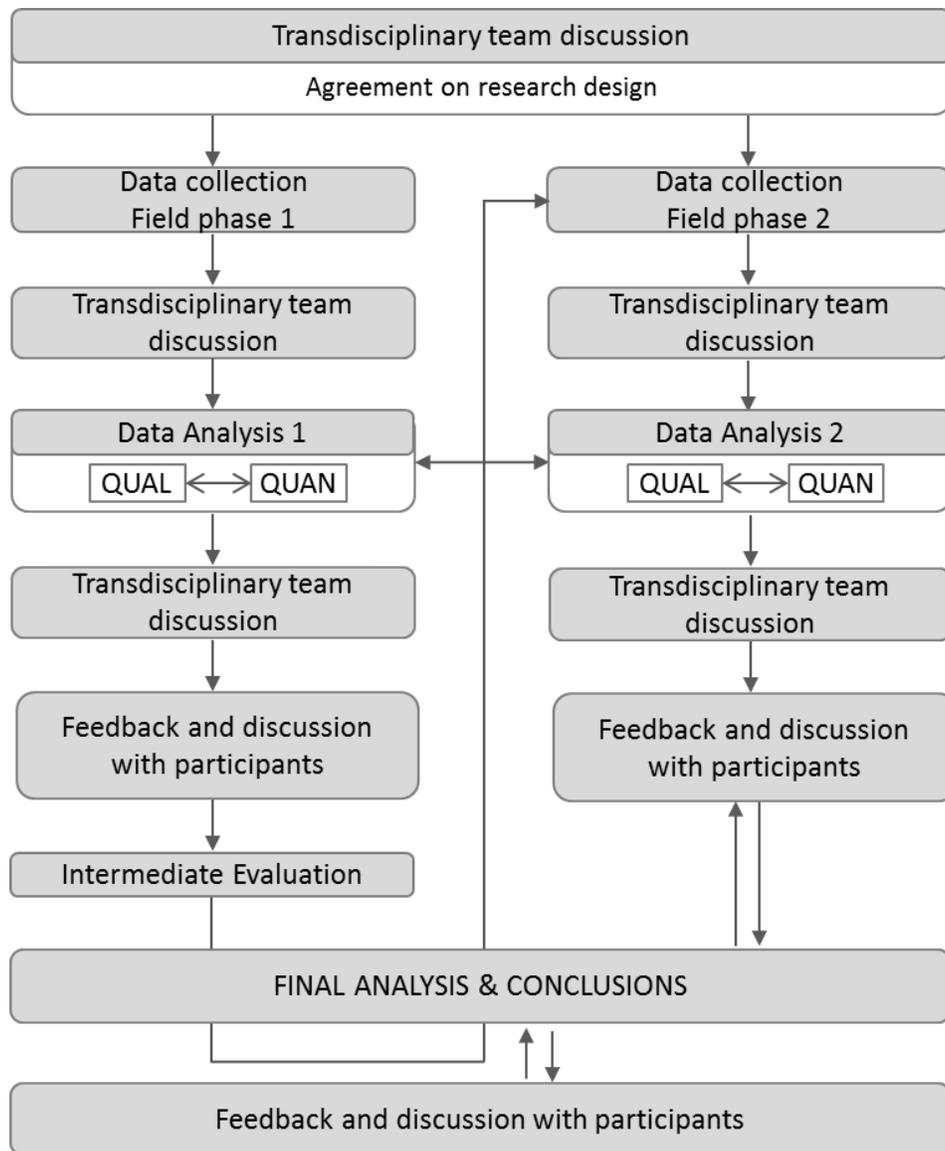


Figure 2. The transdisciplinary mixed methods research design.

Ethical Approval

Ethical approval for this research was obtained from the Health Research Ethics Committee of North-West University, Potchefstroom Campus (NWU-00040-13-A1). Permission to carry out research also was obtained from local municipalities and village chiefs.

Methodological Approach

The data collection tools and sampling frames that were applied for the six dimensions of our conceptual framework during two research phases at multiple levels will be described in the following sections.

Data collection on food security and nutrition. During Phase 1 data were collected from 120 randomly selected households involving three communities, using quantitative research methods. Interviewer-assisted structured questionnaires were administered during four consecutive weekly household visits. Household food security, individual dietary diversity, nutritional status of adult and adolescent, male and female household members, and household food purchasing patterns were determined. This household assessment was a core activity of the whole research project because the collected data and the findings were used to inform data collection in the other dimensions of the framework.

The status of household food security was assessed using a household food insecurity access scale with a set of nine standard items that assign the experience of household food security/insecurity along a continuum from food secure to severely food insecure, over a four week recall period (Food and Nutrition Technical Assistance III Project, 2007).

The standardized Individual Dietary Diversity questionnaire of FAO (2011) that has been used in South Africa by others (i.e., Labadarios et al., 2011) was administered to household members. A dietary diversity score was generated, categorizing reported food items into 10 food groups, guided by Minimum Dietary Diversity for Women (FAO & Institut de Recherche pour le Développement [IRD], 2014). The individual dietary diversity has been found to be positively correlated to nutrient adequacy of the diet (FAO, 2011; FAO & IRD, 2014).

The nutritional status of household members was assessed using Body Mass Index (BMI, kg m^{-2}) with World Health Organization (WHO) standard categories (WHO, 2000) for underweight (BMI < 18.5), normal (BMI $\geq 18.5 \leq 24.9$), overweight (BMI $\geq 25 \leq 29.9$), and obese (BMI ≥ 30). Overweight and obesity are associated with increasing risk of NCDs, such as cardiovascular disease, high blood pressure, and diabetes (WHO, 2015), whereas underweight is associated with nutritional deficiencies including micronutrient deficiencies and related health problems such as anemia (Victoria et al., 2008). Thus, the nutritional status of household members provides insight into health aspects that are important within the context of sustainable diets (see Table 1).

A household food inventory was conducted at the time of the interview, capturing information on the type and amount of food items found in the household (Maunder & Labadarios, 2000). The household food inventory further provided information on brands and packaging of recorded food items. Data of the household food inventory informed the environmental impact calculations undertaken in Phase 2 and described in the next section.

In Phase 2, findings on the household food security and nutritional status were discussed in focus group discussions (FGDs) with community-key informants (i.e., tribal authorities, health workers, dietitians, teachers, and municipality ward councillors) to provide a more comprehensive perspective on the community food and nutrition environment. These FGDs identified perceived reasons for the observed food security situation, dietary habits, and nutritional status. Moreover, existing support structures related to agriculture and nutrition and available resources to promote healthier and more sustainable diets were also discussed (see Table 2 for a summary of data collection tools and procedures).

Table 2

Overview on Data Collection Tools, Sampling Frames, and Analysis Strategy for each Dimension of the Framework

Dimensions of conceptual framework	Indicators	Phase & level of investigation	Data collection method & sampling frame	Analysis strategy
Food security and nutrition	Household food security, nutritional status, dietary diversity	<i>Phase 1 micro</i>	Quantitative methods Household food security: 120 households Dietary diversity: 165 adults, 40 adolescents BMI measurements: 165 adults, 40 adolescents Household food inventory: 80 households	SPSS: descriptive statistics, comparison of means, correlations
	Community food and nutrition environment	<i>Phase 2 meso</i>	Qualitative methods *Focus group discussions: 4 groups with professionals from agriculture and nutrition related disciplines and community members	ATLAS.ti: content analysis
Local food structures	Local production practices, food retail environment, consumers purchasing patterns	<i>Phase 1 meso</i>	Quantitative methods National agriculture and economic data-bases: EasyData (Quantec) and Regional Explorer (HIS Global Insight) GIS spatial mapping: 20 food chain actors Food purchasing patterns: 120 households	MS Office Excel: secondary data analysis ArcGIS: spatial analysis SPSS: descriptive statistics, comparison of means, correlations
		<i>Phase 2 meso</i>	Semi-structured interviews: 33 formal and informal food outlets Structured observations: 33 formal and informal food outlets	ATLAS.ti: content analysis
			Qualitative methods Open-ended guided interviews: 24 large- and small-scale farmers, 5 processors Focus group discussions: 2 large- and small-scale farmers groups	

Dimensions of conceptual framework	Indicators	Phase & level of investigation	Data collection method & sampling frame		Analysis strategy
Environmental sustainability	Food consumption foot prints, land and water use, crop diversity	<i>Phase 2 meso</i>	Quantitative methods		MS Office Excel & Statistica: secondary data analysis ArcGIS: spatial analysis
			Carbon foot print calculations:	40 household food inventories (Phase 1 data)	
			*GIS mapping	Data from municipalities, government, farmers cooperatives, water utility	
			Qualitative methods		ATLAS.ti: content analysis
			*Open-ended guided interviews:	Large- and small-scale farmers	
			*Secondary data analysis:	State of the influence of land and water use and crop diversity on the environment	
Economic efficiency	Economic efficiency from consumer and producer perspective	<i>Phase 2 micro-meso</i>	Quantitative methods:		MS Office Excel: secondary data analysis
			*Analysis of local enterprise budgets and affordability of locally purchased food basket:	Local agricultural cooperatives and retailers	
Socio-cultural aspects	Consumer perceptions and choices, traditional knowledge, intergenerational relations, gender	<i>Phase 1 meso</i>	Qualitative methods		ATLAS.ti: content analysis
			Focus group discussions:	6 groups with men, women and adolescents groups	
		<i>Phase 2 meso</i>	Focus group discussions:	12 groups with women and adolescent girls	
			Traditional cooking practices:	2 groups with girls and women	
			*Document analysis:	historical and ethnographic documents	

Dimensions of conceptual framework	Indicators	Phase & level of investigation	Data collection method & sampling frame		Analysis strategy
Policy framework	Policies that promote sustainable diets, and their local implementation	<i>Phase 2 macro-meso- micro</i>	Qualitative methods		ATLAS.ti: content analysis
			Document analysis:	Primary sources (legislation, regulations, policies, strategies, and programs) and other secondary sources	
			Key-informant interviews: Open-ended guided interviews:	Actors from government or civil society Program beneficiaries and different actors from government, civil society organizations, private sector or citizens	
Overall	Across all six dimensions	<i>Phase 1 + 2 meso-macro</i>	*Key-informant interviews:	Municipalities, government, NGO & CSO, farmers cooperatives, agri-businesses community leaders	ATLAS.ti: content analysis

* Research currently conducted.

Data collection on local food structures. The aim of Phase 1 related to the local food structure dimension was to provide an overview on the agricultural production and local food supply system within the case study area. A quantitative research approach was applied to derive agricultural production and socio-economic data from national agricultural and economic databases and to map the food supply system involving 14 producers and six processors. These 20 food chain actors were purposefully selected according to their products, covering five food groups (i.e., starchy foods, vegetables and fruits, dairy, nuts, and meat).

Also part of Phase 1, information on household food purchasing patterns was collected, such as commonly visited formal and informal food retailers, mode of transport, frequencies of food purchases, and perceptions of consumers regarding food prices, quality, and variety of food items. During Phase 2, results of the household food purchasing patterns informed the follow-up investigations with 33 food outlets that were purposefully selected based on being the most commonly visited food outlets by households. Semi-structured interviews with closed and open-ended questions were used to identify business structures and characteristics, local food supply and distribution, and perceived opportunities and barriers within the local food supply chain. In addition, structured observations on food variety, brand variety, prices, and quality were conducted in the identified food outlets.

Phase 2 further entailed a qualitative inquiry to gain a deeper understanding on farmers' perceptions with regard to sustainable diets. Qualitative face-to-face interviews were conducted with 12 emerging and 12 established farmers, addressing perceptions on economic efficiency of farming activities, environmental impact of farming practices, governmental support structures, contribution to local economy and food security, and the future of farming for Vaalharts. The interview also included a closed questions section, to get additional information on farm, production, other on-farm activities, and client characteristics.

Data collection on environmental sustainability. The data of the household food inventory from the household food security and nutrition dimension were used as a basis to calculate a yearly carbon footprint using the recorded types and amounts of food items as a proxy indicator of household consumption. Data on carbon footprints of the recorded food items were mostly derived from the Barilla Centre for Food and Nutrition (2009) because data on carbon footprints of South African food items were very scarce. The calculations enabled comparisons with international data on carbon footprints of food consumption (i.e., Saxe, Meinert-Larsen, & Morgensen, 2013; Tukker et al., 2011).

Land and water use is currently investigated by compiling a Geographic Information System (GIS) based land use inventory. Databases of existing organizations are utilized first, including those of the national and provincial Departments of Agriculture, the Agricultural Research Council, farmers associations, agricultural cooperatives, municipal planning and service departments, and provincial state of the environment reports. Water use data are obtained from the records of Vaalharts Water User Association, the major water utility of the study area, as well as the regional Department of Water Affairs. Depending on the level of detail obtained, these data are verified and supplemented by questionnaire interviews with randomly selected land and water users, such as food producers (Center for Land Use Education, 2005).

The land use inventory provides the first indication of the crop diversity of the study area, but the detail will be obtained through a survey that is combined with the land and water use verification process. This survey makes use of the optimal combination of structured and open-ended interview methods, to allow for the diversity of farmers from small-scale emerging to large-scale commercial farmers. The results of this survey are incorporated into the land use inventory as an extra layer of data in the GIS.

Analysis of economic efficiency. Determining the economic efficiency in terms of the local food system involves the analysis of both profitability of agricultural production and affordability of food consumption. Measuring profitability of the agricultural activities is currently undertaken by compiling local enterprise budgets for each of the sub-sectors. A standardized (per hectare) net-income is calculated based on local yield potential, input cost, and producer prices for each crop. Subsequently, a sensitivity analysis is conducted to show the impact of changes in productivity and prices on net-income. On the basis of this, a comparison is made on the profitability of the different agricultural ventures in the region.

The measurement of the affordability of consumed foods comprises the collection of price data of a pre-determined basic basket of food products based on the results of the household inventory data, the household food purchasing patterns, and local retail prices as described earlier. Price data are converted to units value in order to make a comparison among products. Relating these prices to the food expenditure of local households will determine the affordability of a nutritionally adequate diet or a basic food basket.

Data collection on socio-cultural aspects. Using a qualitative research design, socio-cultural perceptions of consumers were explored via six FGDs with adult women and men and mixed adolescent groups in two communities in Phase 1. The leading theme of the FGDs was “*Tell me about the foods you usually use in your household and where do you get them from?*” The guiding questions covered aspects relating to, but not restricted to sources of foods; whether the foods are locally produced (within or outside the Vaalharts area); differences in quality perceptions in terms of physical, sensory, health, nutrition, and price attributes; perceived community benefits from existing local food production structures; and perceptions on availability and accessibility.

Phase 2 explored intergenerational transfer of traditional food knowledge, and perceptions and attitudes relating to the use of traditional foods. Twelve FGDs in two communities were conducted with women of three different generations (i.e., > 50 years, 21-49 years, and 14-20 years), separately discussing these issues. Thereafter, two intergenerational culinary sessions took place where mixed generation groups jointly planned and cooked traditional meals, and then evaluated these meals according to taste, look, and traditional food components.

A gender lens is applied throughout the study when analyzing the findings of the different dimensions, including the identification of different perceptions between men and women as well as different gender roles within the context of sustainable diets.

Data collection on policy framework and local implementation. The policy framework shaping sustainable diets was identified by a review of primary and secondary sources within the sectors of agriculture, environment, rural development, land reform, nutrition and health, and social development. Primary sources included official government documents of relevant legislation, regulations, policies, strategies, and programs. Secondary sources consisted of books, journal articles, reports, and electronic resources.

An overview of existing agriculture and nutrition programs in Vaalharts was obtained using a review of existing data collected within other dimensions of the project. Further, key-informant interviews with actors from the government (Provincial Departments of Agriculture, Health, and Social Development) and civil society (i.e., active non-governmental organizations or community members) completed the list of currently running agriculture and nutrition programs in Vaalharts. Three programs relevant to sustainable diets in Vaalharts then were selected for an in-depth investigation, using open-ended guided interviews with key informants at the level of government, civil society organizations, private sector, and program beneficiaries. The aim was to explore determinants of success and failures during implementation strategies of agriculture and

nutrition programs in Vaalharts, to shed light on the role of local governance, and to describe the gap between implementation procedures in theory and practice.

Data Analysis

The design applied here allows for the different research dimensions to be analyzed separately before making meta-inferences (Tashakkori & Teddlie, 1998). Key strategies for data analyses for the applied methods in each dimension are summarized in Table 2. Detailed descriptions of respective analysis strategies will be presented in successive articles on methods and results of individual dimensions of this research. As depicted in Table 2, quantitative data were analyzed using MS Office Excel or IBM SPSS Statistics (Version 21). Simple descriptive statistics, comparison of group means as well as correlations were used to describe the prevalence of specific attributes of sustainable diets—for example, farming characteristics between small- and large-scale farmers, expenditure on food by households at different food outlets, or annual turnover of different food retailers. Spatial analysis with ArcGIS, a GIS, reveals local (i.e., < 50 km) and regional (i.e., 51-220 km) food networks. Transcripts of qualitative data were uploaded into ATLAS.ti Version 7 for content analyses and extraction of themes. Findings of each dimension were added to a matrix that organizes the different themes according to dimensions by rows and the qualitative and quantitative strands by columns. This matrix evolves continuously throughout the research process, with all team members taking part in adding and evaluating emerging themes. This matrix invites and facilitates the team to intensive discussions, to connect themes in a transdisciplinary manner, and to draw conclusions. The meta-inferences are made with findings of both of the data collection phases, all transdisciplinary team discussions, and discussions with participants during feedback meetings.

Participatory Feedback Sessions as Part of Data Analysis and Interpretation Strategy

After each data collection phase, feedback is given to community members, farmers, processors or distributors, and other key informants. After Phase 1 data collection, feedback sessions were held separately with community members and food chain actors (farmers, processors, and distributors) to enable discussions of emerging results and themes to be able to incorporate their views into the data interpretation. This provides a more grounded interpretation of the data. It was intentionally decided to conduct separate feedback meetings because socio-economic and cultural differences among the different study participants might prevent open discussions. The feedback after Phase 2, is planned to include participants from the different groups to enable a dialogue among different food system actors, such as producers, consumers, policy makers, and civil society. Achievements towards more sustainable diets would be influenced by a common understanding among all food system actors.

Ensuring Validity

Several procedures are applied to ensure validity with respect to data quality, interpretative rigor, and inference transferability. Validity and reliability strategies for the quantitative research components include: applied sampling processes, reports on the number of respondents and non-respondents, discussion of response bias, descriptive analysis of all data, and reports on statistical significance testing (Creswell, 2014). For qualitative the data, the following strategies are employed to ensure validity: data triangulation, member checking, prolonged time spent in the field, the inclusion of participant information into the data analysis process, in-depth descriptions, reflection of researcher's bias, peer debriefing and external audits, transcript checking, coding rigor by continuously comparing data with established codes and application of codebook, and inter-coder agreement (Creswell, 2014). The designation of this as a mixed methods research process was assessed using the comprehensive quality framework by O'Cathain (2010). Care is taken not to generalize beyond the given case study.

Discussion and Conclusion

As this article demonstrates, exploring sustainable diets requires a transdisciplinary framework and innovative mixed methods research strategies in order to address the complex nature of this concept. The comprehensive research approach, addressing the six dimensions of the sustainable diets framework has generated a large amount of data. A detailed presentation and discussion of the results of this study falls outside the scope of this article and will be addressed in succeeding publications.

The case study design applied here allowed not only for in-depth investigation of a contemporary phenomenon within a real-life context, but also for different data sets to be merged in a triangulation fashion (Yin, 2014). The adoption of a two-phase design that combines concurrent approaches served to address linkages among the various dimensions of the conceptual framework. Creswell and Plano Clark (2011) argue that multi-phase designs are commonly applied in large-scale studies over a longer period of time, especially in the field of program evaluation. Our study illustrates that multi-phase programs can contribute to in-depth explorations when incorporated in qualitative case study designs, supporting a flexible approach as was followed throughout the course of this study.

Comprehensive research on sustainable diets can be achieved through a collaborative team effort that integrates researchers from different disciplines with both qualitative and quantitative research expertise. Uniquely, our approach involved stakeholders from the community to ensure that the socio-economic and cultural environment was adequately reflected and interpreted. Among the challenges of this collaborative approach, especially experienced in Phase 1, was that some of the invited experts were not able to invest the time required for the extensive collaborative processes of transdisciplinary work and related discussions. A particular benefit for each team member of this complex multi-disciplinary research collaboration is that they are enabled to produce individual publications, while contributing to the overall aim of the project and to a more comprehensive understanding of the complex subject investigated.

The conceptual research framework applied here was designed specifically to address rural resource-poor settings in Vaalharts, South Africa. Applying a conceptual framework provides theory-based results and supports research credibly and transferability. However, an incompatible framework might distort data collection and findings (Evans, Coon, & Ume, 2011). We assume that the conceptual framework applied here is compatible to the study area. Regular communication and feedback meetings with community members ensured continuous reflection on the research process and the conceptual framework. Feedback meetings also serve as a platform to establish awareness about the complexity of sustainable diets, and contribute to the planning and designing of possible community-based interventions that promote more healthy and sustainable diets in the setting.

In addressing the six dimensions of the concept of sustainable diets in the given framework, we are aware that only a selection of indicators could practically be focused on. Other relevant indicators discussed in the literature, particularly referring to health, equity, and quality (Johnston et al., 2014; Lairon, 2012; Lang, 2012) have not yet fully been addressed here, but might be subject to future follow-up research. Findings of this case study further may not be directly transferable to the broader South African context, or to other countries, because the dimensions of the framework are context specific. Findings of this research contribute to the larger international debate on sustainable diets by providing rigorous empirical data and detailed insights into certain dimensions of sustainable diets. More empirical research that applies a similar framework in other parts of South Africa or other regions is needed to enable cross-regional or cross-country comparisons. Such research would enable us to extract key indicators that are of substantial

relevance to measuring sustainable diets for South Africa and can contribute to providing future policy and program development direction towards achieving more sustainable diets.

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