Preventing stunting in Madagascar; An analysis of nutrient access

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Master in International Health
March 2013 – September 2016

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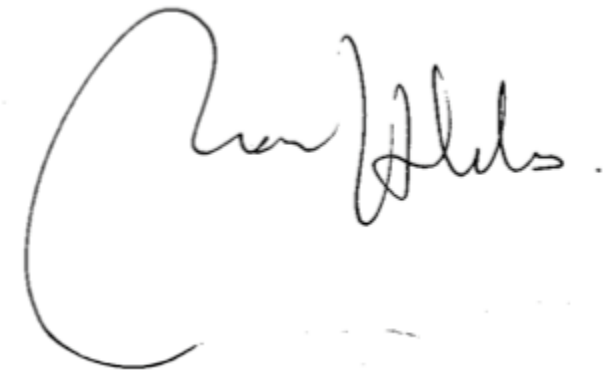

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Abstract

In 2015, Madagascar is among the five countries in the world which rank highest in stunting with nearly fifty percent of children under five affected.

Poor nutrient access can result from a limited availability of nutrient dense foods and/or from a financial incapacity to purchase these foods. As stunting directly results from gaps in nutrient intake in the first thousand days of life, an accurate understanding of the drivers and barriers to nutrient access in pregnant, lactating women (PLW), adolescent girls and children under two is key to preventing stunting effectively.

The purpose of this study was therefore to determine whether barriers for improved nutrition in Madagascar were due from availability or affordability of nutritious food or both.

The study responded to the following research questions.

1. What macro and micronutrients are the most difficult to meet from locally available foods - the limiting nutrients - to cover the requirements of children under-two, adolescent girls and PLW?
2. What is the cost of a nutritious diet for a whole household, including children under 2, adolescent girls and PLW?
3. Can poor households afford the cheapest locally available balanced diet?
4. For the households that cannot afford a nutritious diet, what additional level of income would be needed to reach nutrition security?
5. What are the current feeding practices and food taboos specific to children under two, adolescent girls and PLW?

For this purpose, the study used a standardized methodology called the Cost of Diet (CoD). From an inventory of all locally available foods and their retail price on markets, this method optimises the minimum cost of a nutritious diet, i.e. the cost of the least expensive combination of food items available on local markets that meets all nutrient requirements for a household. This cost is then compared with households' income to its affordability.

Results from our study highlight that except for the regions near the capital city, the country presents a very low availability of nutrient-dense foods with 25 to 45 non-staple food items in local markets. Availability of essential animal-source foods is particularly low in the highlands and Eastern regions, regions with some of the highest stunting rates.

In addition, generalized poverty hampers communities' capacity to afford the cheapest combination of foods that would cover the nutrient requirements of a typical household. Poor households would require income increase of 5,000 to 11,500 Ariary per day to afford the cheapest nutritious diet.

These issues of access to nutrients have a direct impact on the nutritional status of individuals, illustrated by strong correlations found between stunting in children under five and low food availability on the market on one hand, and households' low capacity to afford a nutritious diet from locally available foods on the other hand.

Compared to similar analysis undertaken in other countries, access to nutrients in Madagascar is outstandingly low. Even if the methodology generates a theoretical diet and is only valid for the post-harvest season, the findings provide useful indication to develop strategies aiming to increase nutrient intake in the first thousand days.

Strategies seeking to improve nutrition outcomes for the most vulnerable households will have to take into account the low availability of nutrient-dense foods and the issue of affordability of nutrients across the country. Such strategies will be indispensable for Madagascar to have a chance to reach the new global goals in 2030.

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List of acronyms

In alphabetical order

BCC: Behaviour Change Communication
CAP: Knowledge Attitude Practices
CoD: Cost of Diet analysis
FAO: Food and Agriculture Organization
IYCF: Infant and Young Child Feeding
MGA: Malagasy Ariary
NGO: Non-Governmental Organisation
ODR: Observatoire du riz
ONN: National Office for Nutrition
LNS: Lipid-based nutrient supplement
PLW: pregnant and lactating women
PNAN: Plan National d'Action en Nutrition
RNI: Recommended Nutrient Intake
SNUT: Staple-constrained nutritious diet
SUN: Scaling Up Nutrition
UNICEF: United Nations Children's Fund
USD: United States Dollars
WASH: Water, sanitation and hygiene
WFP: World Food Programme
WHO: World Health Organization

Keywords:

Stunting, nutrient, food security, malnutrition, undernutrition, Madagascar

1. Background information

Hunger describes a state where an individual is not getting enough food in quantity and quality to conduct an active and healthy life. This is the accepted term that relates to both food security and malnutrition. Although hunger has decreased by nearly 20 percent in the last 20 years, it still affects an estimated 795 million people, or one in nine people in the world in 2015(1). Despite global progress, sub-Saharan Africa remains the region with the highest prevalence of undernutrition and showing slowest improvement in recent years(2)(3).

Undernutrition impacts the overall health and economic potential of both individuals and countries. Globally, it causes 45 percent of all deaths of children below the age of five, representing more than 3 million deaths each year. Undernutrition is found to be responsible for 10 percent of morbidity and a productive loss of 56 million dollars each year(3)(4).

Inadequate nutrition in the first thousand days of life – from conception to a child's second birthday - leads to irreversible impairment in physical growth and cognitive development. There are three primary life-cycle stages in the first thousand days of a child's life: growth in utero; the first six months of life when the infant should be exclusively breastfed; and the next 18 months of life as the child makes the transition from consuming only breast milk to consuming the family meal, greatly increasing exposure to pathogens. The effects of inadequate nutrition during the first thousand days are inter-generational(5).

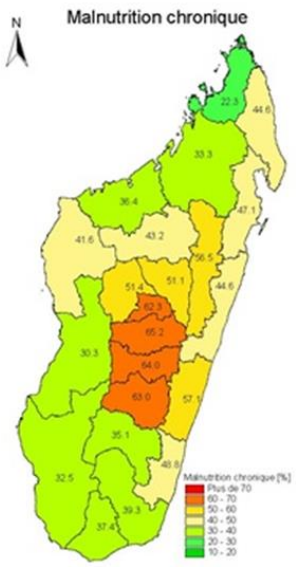
At individual level, stunted children earn an income that is 20 to 65 percent less as adults. Whereas children who receive adequate nutrition may earn wages nearly 50 percent higher as adults(4). The impact of high malnutrition rates on the national scale equate to reduced productivity, impaired economic growth and increased poverty. This constitutes a major barrier to the country's development(5). An analysis estimated that Madagascar loses 9 percent of Gross Domestic Product each year due to malnutrition(6).

The latter statement applies particularly to Madagascar where undernutrition is widespread. The country shows some of the highest rates in the world(7). According to figures from 2012, nearly half of children under-five are chronically malnourished - or stunted - and 8 percent are acutely malnourished - or wasted, while anemia affects 35 percent of women aged 15-49 years and 50 percent of children under five(8).

Madagascar is a low-income food-deficit country, ranking 155th out of 187 countries in the 2014 Human Development Index(9). The country has experienced political instability since independence in 1960. In 2013, 90 percent of its 22 million inhabitants lived below the World Bank poverty line of 2 dollars a day. One quarter of the population live in areas highly vulnerable to frequent natural disasters. Due to their adverse impacts on agriculture, these natural hazards are a major threat to a household's ability to cover their food needs. In 2014, an assessment found that 35 percent of the rural population was food insecure. The highest rates of food insecurity were in the regions characterized by eroded land and drought or in the regions prone to cyclones and flooding. Climate change is likely to exacerbate these risks and further increase household vulnerability(10).

The closure of a significant number of primary health-care centres during the political crisis, coupled with an insufficient number of qualified health staff, has caused a decrease in health service attendance and has raised concerns about child and maternal health. Child and maternal mortality remains high at 56 per 1,000 live births and 440 per 100,000 live births respectively(7)(8).

Over the last decade, the government of Madagascar has taken measures to address the issue of undernutrition. In 2004, a national office for nutrition was created under the Prime Minister's office to coordinate nutrition matters within the government and ensure a multisectorial response to the problem of malnutrition. The Ministry of Health developed a national protocol for the management of acute malnutrition and progressively integrated acute malnutrition treatment in the National Health Service. This country-wide measure resulted in a reduction of the national wasting prevalence from 11 to 8 percent - under the international critical thresholds of 10 percent(11). In parallel, a large-scale intervention to reduce stunting was implemented through 8000 nutrition community workers delivering preventive activities in 4000 localities throughout the country. An evaluation of this community-based programme seeking to prevent stunting was undertaken in 2011. It highlighted many challenges and a limited impact on stunting. The main recommendation from the evaluation was to focus interventions on the first thousand days of life. Today, the national average prevalence remains high, affecting nearly 50 percent of under-five children(12).



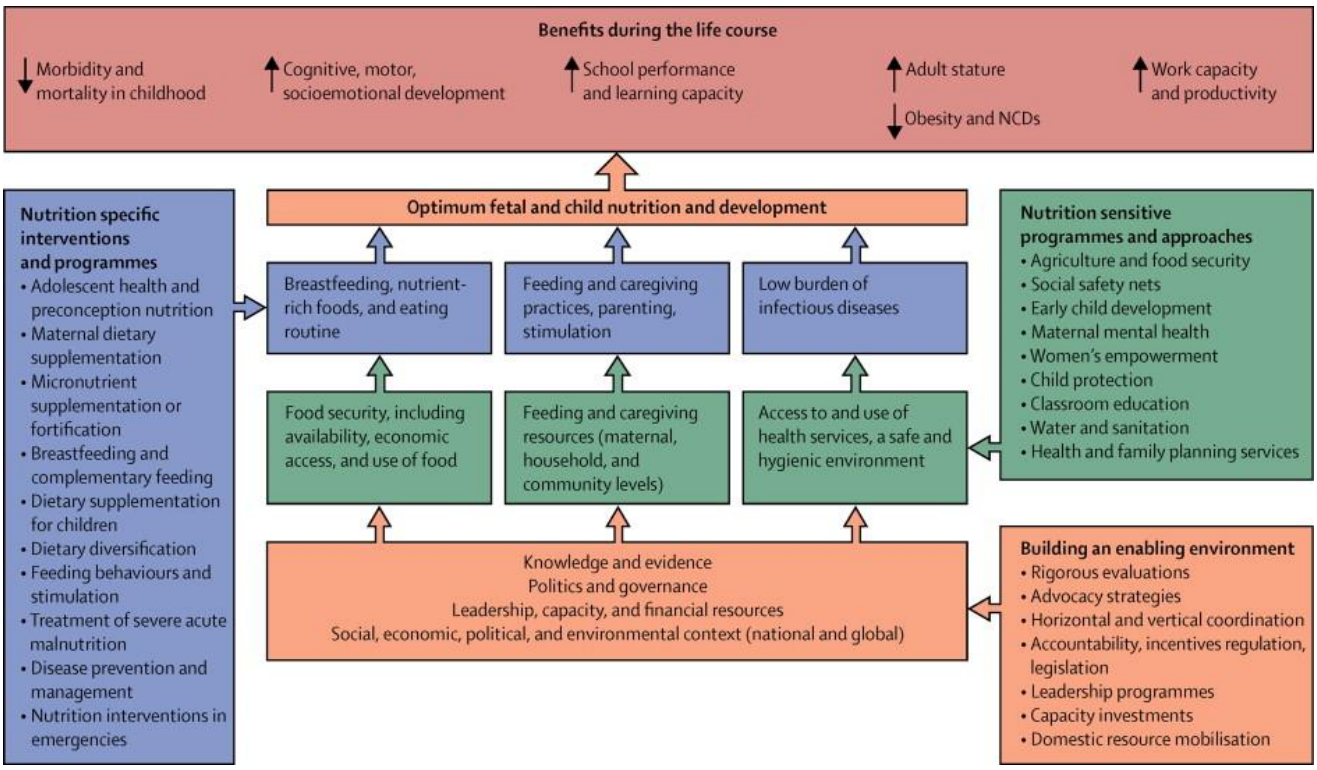
Map 1: distribution of stunting in Madagascar. Source: MDG survey 2012/2013

With a national average of 47.3 percent stunting in children under five, the distribution of stunting within the different regions of Madagascar represents something of a paradox (see map 1). The regions in the interior of the country, in the highlands, show stunting rates above 60 percent. However, these regions are where the food production is the highest with a large diversity of fruit, vegetables and legumes. The regions along the coast have lower rates of stunting between 30 and 50 percent, regions with lower opportunities for food production(8). To this day, the causes for this paradox are not well established. This study calls for research which can contribute to better understanding of this paradox, i.e. an understanding of the determinants of stunting in the central and coastal regions, and in doing so, support the country's social and economic development.

2. Problem statement and justification

A further understanding of the drivers of malnutrition in Madagascar will support better policy development and programme design to effectively address the issue of malnutrition. The universally accepted conceptual framework for describing malnutrition (Figure 1) presents the multiple causes of malnutrition, which can be classified into direct, underlying and environmental causes.

Figure 1: the conceptual framework of malnutrition. Source: Lancet series on nutrition 2013



The framework shows that the direct causes of suboptimal nutrition – dietary intake, care practices and disease – are themselves determined by sets of underlying causes. Food security, local availability of foods and economic power to access this food, both in adequate quantity and quality, are important determinants for an individual to meet all their nutrient requirements. The overall environment shapes the decisions that are made at household level and impacts an individual's nutritional status.

As an illustration of this causal link, global evidence demonstrated that the 2008 financial crisis, resulting in rising food prices, affected food consumption and aggravated malnutrition(2)(13)(14). Thus, in communities where the main food consumed is rice, as it is the case in Madagascar, poor households with a reduced purchasing power, continued to purchase rice and reduced

their consumption of non-staple foods. Non-staple foods, such as meat, fish, dairy, fruit and vegetables, are more nutrient-dense than staple foods. A recent study established that families purchasing less non-staple foods and purchasing more staple foods presented a higher risk of child chronic malnutrition(15). This illustrates how purchasing power can be a barrier to access nutrient-dense foods and therefore meet essential nutrient requirements.

In addition, the Lancet conceptual framework defines sets of 'nutrition-specific', 'nutrition sensitive' and 'building an enabling environment' interventions addressing respectively immediate, underlying and basic causes of malnutrition. These interventions have been demonstrated effective in reducing malnutrition in similar settings.

In the particular context of Madagascar, poverty is largely widespread with 90% of the population living under the poverty threshold of 2 dollars a day and 70% under the extreme poverty threshold of 1 dollar a day. The link between poverty and malnutrition is particularly strong: traditional programmes of nutritional education promoting diet diversity have shown limited impact due to the economic constraints faced by the majority of households(16)(8).

It is important to note that dietary intake is not the only determinant to malnutrition. Other factors influence an individual's nutritional status. These factors include, but are not limited to, access and quality of health services, access to potable water, sanitation and infant and young child feeding practices. However, ensuring an adequate nutrient intake is a minimal condition to improved nutrition outcomes. Even if health and sanitation conditions are important as they influence nutritional status, they cannot ensure adequate nutritional status on their own. Nutrient intake must be met in the first place for any individual to ensure an adequate nutritional status(17).

As stunting results from gaps in nutrient intake in the first thousand days of life, ensuring adequate nutrient intake to pregnant and lactating women and children under two represents a window of opportunity for preventing stunting. In addition, early sexual intercourse is a frequent behaviour in Madagascar, often causing teenage pregnancies. According to a study from 2012, 20 percent of adolescent girls had their first sexual intercourse before age 15(18). In a household, pregnant and lactating women, adolescent girls and children under two have the highest and most specific nutrient needs, increasing their vulnerability to undernutrition.

In the context of Madagascar, this analysis therefore proposes to contribute to a deeper understanding of the drivers and barriers to nutrient access of women, adolescent girls and children. In particular, the analysis proposes to assess if nutrient access is hampered because food that is locally available cannot cover nutrient requirements, or the food that is locally available allows nutrient requirements to be met but households are financially incapable of purchasing it or both. The findings of this study will then provide useful insights for the development of strategies to reduce stunting during the first thousand days.

3. Objectives

The overall goal of the research was to contribute to the national understanding of determinants of undernutrition in Madagascar to support nutrition and food security programme and policy development.

Specifically, the research sets out to:

- Assess nutrient access of households, in particular for children under two, adolescent girls and pregnant and lactating women (PLW) per zone
- Determine to what extent food availability and/or affordability limit nutrient intake per population group, per zone, and per nutrient
- Review current feeding practices and taboos related to children under two, adolescent girls and PLW that may prevent form adequate nutrient intake in the case availability/affordability of nutrients is not an issue
- Recommend interventions that could be considered to improve nutrient access per population group, per region and per nutrient, taking into account availability and/or affordability of nutrients, local food habits and taboos

To this end, the study responds to the following research questions:

1. What macro and micronutrients are the most difficult to meet from locally available foods - the limiting nutrients - to cover the requirements of children under-two, adolescent girls and PLW?
2. What is the cost of a nutritious diet for a whole household, including children under 2, adolescent girls and PLW?
3. Can poor households afford the cheapest locally available balanced diet?
4. For the households that cannot afford a nutritious diet, what additional level of income would be needed to reach nutrition security?
5. What are the current feeding practices and food taboos specific to children under two, adolescent girls and PLW?

4. Methodology

4.1 Cost of Diet

1.1.1. Introduction and conceptual framework

For this purpose, this study was designed using a quantitative approach, through a standardized methodology which has been specifically designed to assess nutrient access in a humanitarian context. This methodology is called the Cost of Diet (CoD). From an inventory of all locally available foods and their retail price in local food markets in a given livelihood zone, this method calculates the minimum cost of a local balanced diet, i.e. the cost of the least expensive combination of food items available on local markets that meets all nutrient requirements for a household. This cost is then compared with households' income and food expenditure to analyse the affordability of a nutritious diet.

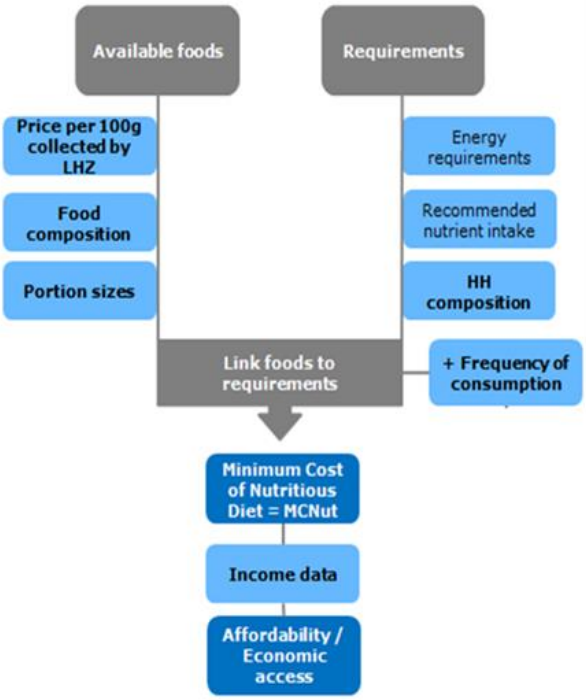


Figure 2: Conceptual framework of the Cost of Diet. Source: Cost of Diet, a practitioners guide, Save the Children UK

This is the first time such a study has been undertaken in Madagascar. The methodology was developed by the Non-Governmental Organisation (NGO) Save the Children (19). As the study of nutrient access raised interest in a large number of nutrition and food security stakeholders, Save the Children conducted a review of available studies and led consultations among users of the Cost of Diet analysis in order to refine the methodology and develop a software. The version used in this analysis integrated improvements and best practices collected from the various reviews and consultations, and was validated by the broad consultation group. This study work did not deviate from the second version of the methodology as this will ensure comparability of results with studies performed in other countries.

For the CoD methodology mixed sources of quantitative data are needed (figure 2):

- secondary data on household size through the latest national population survey
- secondary data on food composition through food tables

- primary data of food prices through market surveys
- primary data on local food habits and consumption frequency per food through rating questionnaires
- secondary data on household income through the latest national household survey per zone

1.1.2. Primary data collection and sampling

Map 1 Livelihood and agro ecological zones in Madagascar. Source: World Food Programme

This study was conducted in 10 zones that represent the 10 main livelihood and agro ecological zones in the country. The zones are numbered from 1 to 10 from North to South (see map 2). Details on agro-ecological specifics and the administrative regions covered by each zone are provided in annex 1. In each zone, the price, the availability of foods and ways of generating income are reasonably homogenous. The Cost of Diet is not a rigorous quantitative method and therefore does not need to be statistically representative.

The focus of this study was to investigate how rural Malagasy households access nutrients. The urban areas were excluded as market analysis shows that more foods are likely to be available and household surveys show higher levels of income in an urban setting compared to a rural setting.

For primary data collection, six markets were selected in each of the 10 zones, in a total of 60 markets. After the market survey was completed, a purposely selected group of 4 clients from the market, preferably women, participated in an interview on dietary habits. The aim of the interview was to establish the acceptable frequency of consumption of the different foods. The method takes into account that in rural areas, households have access to wild foods for free (text box 1).

Text box 1: Free foods

In Madagascar like in most African countries, leaves, roots, fruit, insects and game hold an important place in traditional diets, in particular for the poorest households. Adjustments are thus made for foods that have no monetary value by collecting information on the consumption of these free foods during the interviews and including their consumption in the diet, setting the price of these foods to zero.

The data collection took place in August 2015 for a duration of 4 weeks. Details on sampling and procedures used for data collection are provided in annex 1 and 2.

1.1.3. Parameters definition

Based on the latest national population survey, the typical household considered in the study is composed of 5 members. For the purpose of studying nutrient access in the first thousand days, the household members were arbitrary chosen as below:

- 1 x Man, 30-59 years, 65 kg, moderately active
- 1 x Lactating woman, 30-59 years, 50 kg, moderately active
- 1 x Adolescent girl 14-15 years
- 1 x Child (either sex) 6-7 years
- 1 x Child (either sex) 9-11 months.

The CoD takes into account the recommended nutrient intake (RNI) in energy, macronutrients for protein and fat, and micronutrients for vitamin A, C, B1, B2, Niacin, pantothenic acid, B6, folic acid, B12, calcium, iron, magnesium and zinc (see details on energy, fats, protein and micronutrient specifications in annex 3). Iodine is not evaluated through this methodology.

1.1.4. Data quality

During the data collection phase, the survey sheets were reviewed at the end of each market survey to check for missing data or incoherence. After data entry, the software flagged all outstanding discrepancies in food prices per 100g within each livelihood zone. These flagged data were discussed with the data collection teams and either corrected or excluded.

The prices of food items collected through this study was compared with prices of similar food items collected in the same zones, during the same month, to ensure coherence (results are featured in section 'results').

4.2 Analysis

This analysis started by reviewing the availability of foods from the food list in local markets, in particular for non-staple foods with higher nutrient density. The availability of nutrient dense foods was then compared to the prevalence of stunting in the same zones to check for correlation.

After data sets were checked for quality and reviewed, the database in the CoD software programme contained the list of all available foods, their price per 100g, nutritional composition, portion size and frequency of consumption. Through linear optimisation, the software linked food with nutrient requirements and generated, from locally available foods, a nutritious diet for our typical household, at the lowest cost. Any other diet at the same price was less nutritious, and any other diet of the same nutrient value was more expensive. For each food item from the food list, the frequency of consumption data was used to set minimum and maximum frequency constraints for each available food. In addition, staple constraints were manually added to ensure staples were imposed in the diets to a minimum of once a day and a maximum of 3 times a day. For each zone, the cheapest rice was chosen as the main staple, apart from the Southern region where maize, cassava and sweet potato were chosen as the main staples as per local eating habits. The diet generated by the software programme based on all of the above, was a **s**taple-constrained **nut**ritious combination of locally available foods, referred to throughout this paper as SNUT.

For each of the 10 zones, the software programme calculated the SNUT and produced the following outputs for each member of the household and for the entire household (see the detailed example of a SNUT diet in annex 4:

- The list of food items composing the SNUT
- The daily quantities of foods selected for the SNUT
- The daily number of servings of these foods
- The cost of the SNUT food combination
- The daily quantity of each nutrient provided by the edible portion of foods
- The percentage of each nutrient target provided by the edible portion of foods

For each zone, the composition of the SNUT was studied to identify the limiting nutrients for our three vulnerable groups and the main food sources providing these limiting nutrients.

This cost of the SNUT was then compared with households' income to analyse its affordability. A diet may have a low cost but if it is not affordable by the poor then the risk of malnutrition remains. The capacity of very poor, poor and average households to afford a nutritious diet was estimated for each zone, including the amount needed for a poor household to afford the SNUT. In addition, the affordability the SNUT measured through this study per zone, was compared to the prevalence of stunting in children under five in the same zones.

Lastly, a literature review was performed on food taboos and practices for infants and young children feeding (IYCF), adolescent girls and PLW feeding to assess in these vulnerable groups the current habits related to nutrient intake that are specific to Madagascar.

4.3 Limitations and mitigating measures applied

Evidence review for the Cost of Diet application has revealed several limitations:

- Diets generated through this analysis are theoretical and the quantities selected by the software for certain foods may not be realistically consumable. To mitigate this limit in this study and generate culturally acceptable diets, parameters were applied to constrain the software, e.g. the consumption of staples was imposed at least once a day, or between 7 to 21 times per week.
- Accuracy to properly factor in the role of wild food. Based on an evaluation of the methodology in Tanzania, a reduction of 20 percent was applied in this study to the final cost to take into account that wild foods constitute a substantial part of rural households' diet, even more so in the case of poor households(20).
- Households' additional expenses linked to essential non-food items and services make a significant difference to affordability, which methodologies fails to consider. In this analysis, the use of food expenditure as 75 percent of total expenditure attempts to take into account that households will use part of their income for other priorities than food.
- Seasonality of foods is likely to vary therefore results are only applicable to the period covered. The study intends to cover the month of August, which is the end of harvest in most of the regions. The findings are therefore valid for this period only.
- Estimation of income. The standardized and widely used approach of combining value of food production and cash from sales and employment has limited sensitivity. In our study, secondary data of total household expenditure is extracted for each of the zones from the most recent national household survey undertaken in December 2012(8). For accuracy of affordability analysis, income data and price data should be collected in the same year. 2012 income data were therefore adjusted according to income variation trends to take into account that the purchase power of households in August 2015 increased from 2012. An increase of 5 percent was applied(21).
- In rural Madagascar 80% of the population live from agriculture(22). Households sell part of their production, even if they do not have any cash crops or surplus production of food crops, to generate cash for various purposes. Part of the vegetables and staples own-produced in at least part

of the year may be consumed. The consumption of own-produced foods is evaluated from complementary studies in the discussion section.

- Iodine deficiency is a significant cause of mental disability in children. Although iodine plays an important role in brain development and function, the coverage of iodine requirements in the first thousand days is not evaluated through this study.

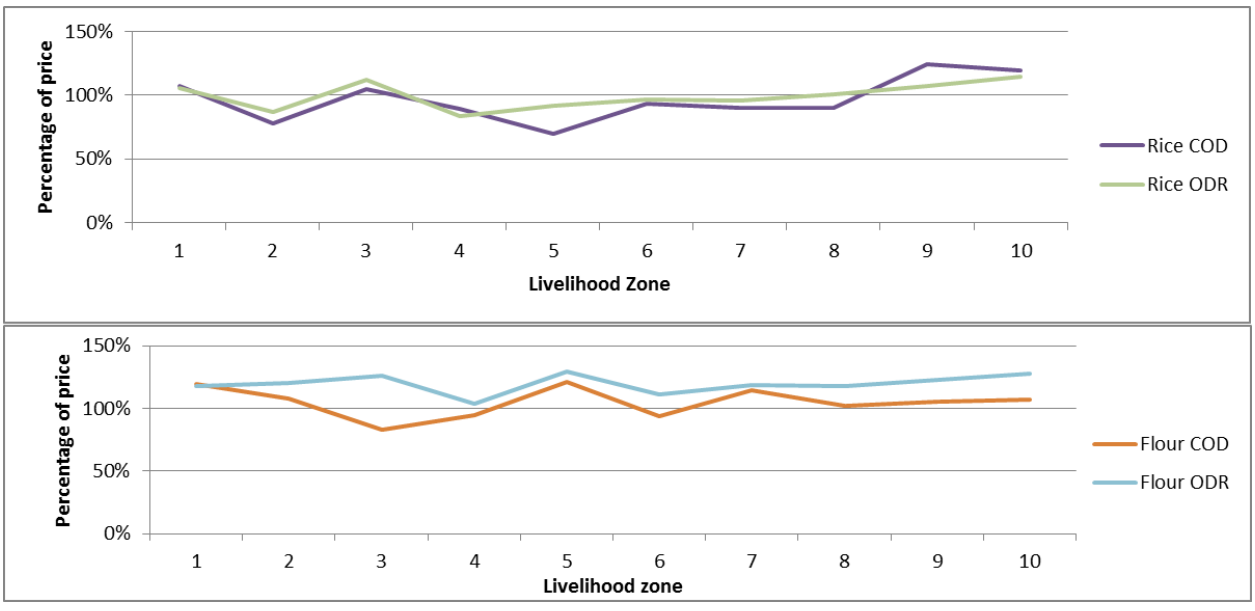
5. Study results and findings

Section 5.1 follows the established research questions. After results on data quality, the availability of nutrient dense food will be presented and linked with stunting rates. This section will then discuss the SNUT per zone. This includes the main limiting nutrients per vulnerable group, their food sources and the cost of the SNUT. Affordability of the SNUT will then be analysed per zone and related to stunting rates. Ultimately, feeding practices specific to Madagascar will be reviewed to further understand cultural barriers to adequate nutrient intake. Section 5.2 will summarise the key findings from this study.

5.1 Results

5.1.1 Results from data quality tests

As part of a national price monitoring system 'observatoire du riz' (ODR), prices for rice and flour are collected by the National Institute of Statistics in Madagascar. ODR prices are monitored in 120 markets on a monthly basis. ODR price data from the month of August 2015 were compared with the average price per 100 gram for these two items collected in this study (CoD) in each of the 10 zones. As CoD prices were collected from a smaller sample of 60 markets, this comparison contributes to check for data quality.



Graph 1: Comparison between CoD and ODR average price for rice and flour per zone

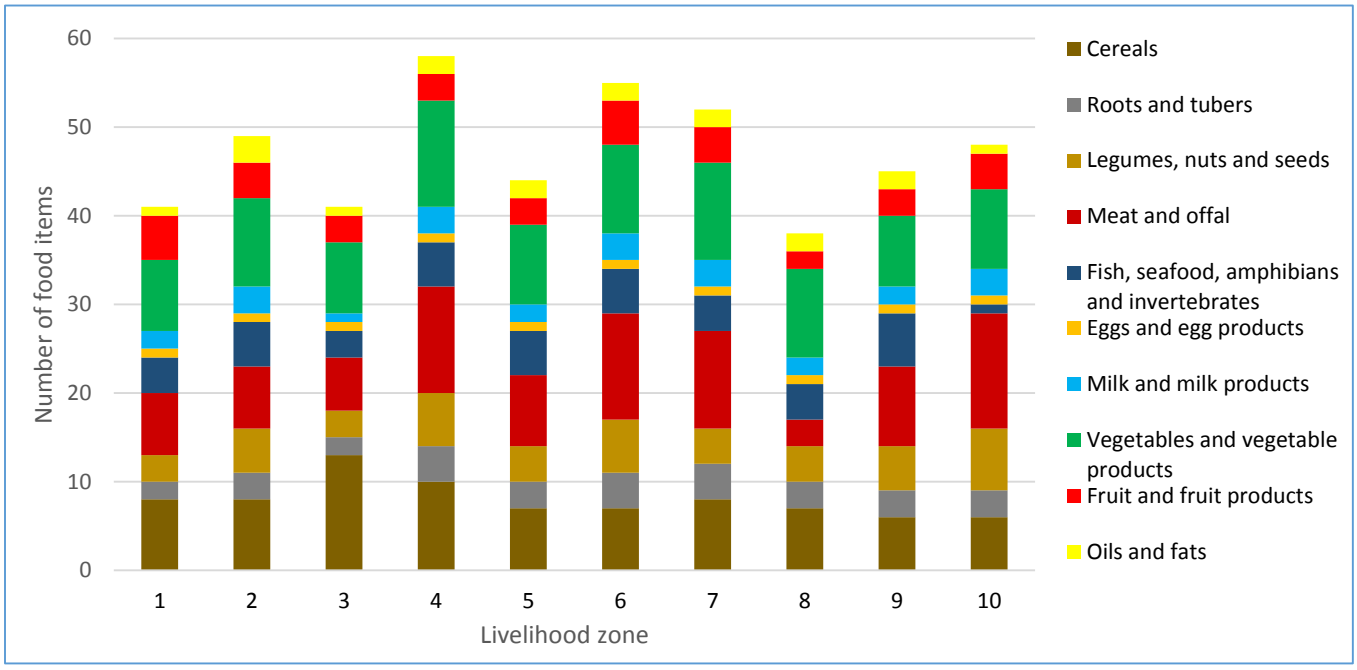
The variation in the average CoD price follows the trends of the ODR average price variation for rice and flour in most of the livelihood zones (graph 1). An exception can be noted in zone 3 for the price of flour and in zone 5 for the price of rice.

Overall, from the data quality tests and the comparison with existing official data, it can be concluded that the quality of the data collected for the purpose of this study is satisfactory and coherent with other available data from the same zones.

5.1.2 Availability of food

Before running the cost optimisation, the market survey data sheets were analysed to indicate the availability of foods for each food group in each zone. As such, graph 2 presents the number of food items out of the 130 food items from the food list, available on the market at the time of the survey, per zone. At the moment when the data was collected, less than 50 percent of the food items from the food list were available in all the markets surveyed. The zones with the least available food items are the extreme North, East, West and the highlands (zones 1, 3, 5 and 8).

Graph 2: number of food items out of 130, available on the market, per zone and food type

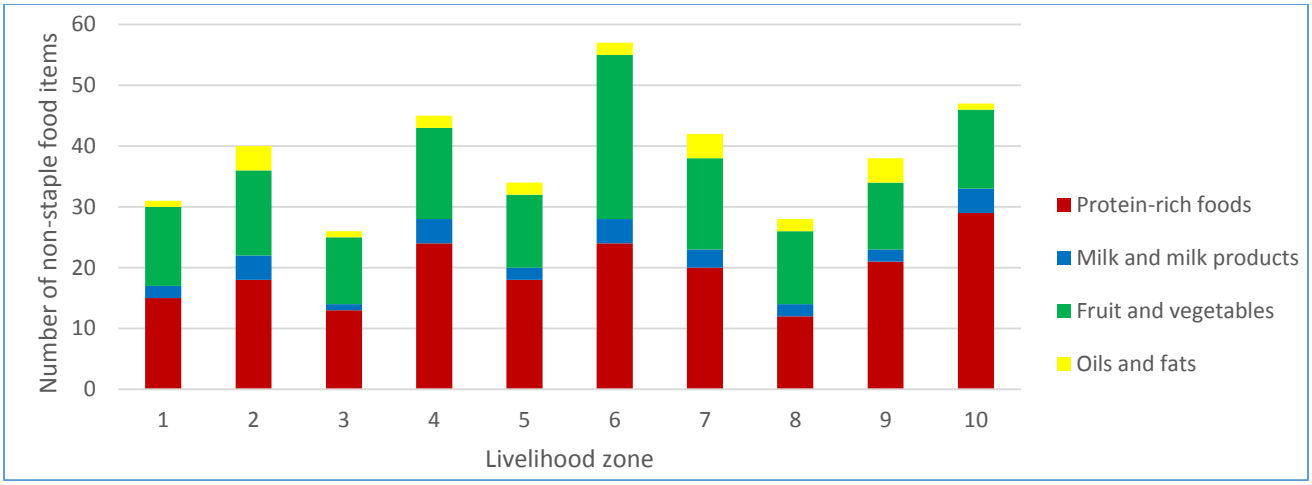


Fish items are rare in the most central regions of the country (zone 8). In the southern regions (zone 10), where cattle herding is an important activity,

meats and offal are the most available. The East (zones 3 and 4) present the highest availability of staple-foods, i.e. cereals, roots and tubers.

Availability of non-staple foods - or nutrient-dense foods - classified into fruit and vegetables, milk and milk products, protein-rich foods and fats, was taken from the above set and further analysed (graph 3).

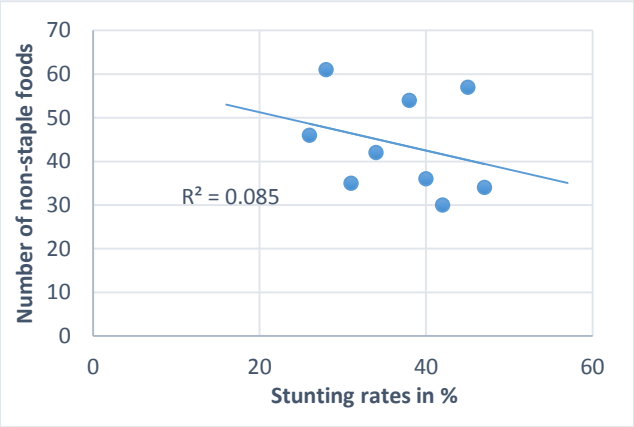
Graph 3: number of non-staple food items available on the market per livelihood zone



The regions surrounding the capital city of Antananarivo (zone 6) are the most connected, serviced by 7 national roads. They benefit from favourable market dynamics due to easier transport access for suppliers. Availability of non-staple foods does not seem to be an issue in this zone.

The other zones are affected by poorer transport infrastructure. Communities in remote areas depend on locally produced foods. The extreme North, East, West and the highlands (zone 1, 3, 5 and 8), present the lowest availability of nutrient-dense foods. The South (zone 10) has a high availability of meat and offal items on the market due to important cattle herding activity, but availability of other foods such as fish or vegetables is also low. In remote areas, households have a low diversity of nutrient-dense foods to choose from, between 25 to 45 items in the markets visited, with half of the food items from animal sources.

5.1.3 Stunting and food availability



Graph 4: correlation between the number of non-staple foods available on the market and stunting in each zone.

From national statistics, the zones with the lowest food availability and diversity within a food group are the zones that record high stunting rates, from 35 to 61 percent prevalence in children under five(8). In the zones where animal-source foods are the least available, zones 3 and 8, the prevalence of stunting is critically high with, respectively, 46 and 61 percent. Graph 4 outlines a correlation (R square = 0.085) between the rates of stunting in children under 5 and low availability of non-staple foods on the market. A higher non-staple food availability and diversity is associated with lower rates of stunting in children.

Indeed, low availability and diversity of nutrient-dense foods can induce nutrient gaps, hampering households from meeting their nutrient requirements.

5.1.4 SNUT per region

5.1.4.a Limiting nutrients

After linear optimisation and definition of SNUT diets from the locally available foods, the analysis highlighted the nutrients that were the most difficult to cover for each member of the household and for each zone, referred to as 'limiting nutrients' (table 1).
From the results of this study, fat, folic acid, calcium and iron are 'limiting nutrients' for women, adolescent children and children from 9 to 11 months in nearly all the regions. Zinc is a limiting nutrient for children under two in the Northern regions of the country. Vitamin C and A are additional limiting nutrients for the adolescent girl and the lactating woman in the central regions.

		Macronutrients			Micronutrients											
Livelihood zones	**Target group**	**Energy**	**Protein**	**Fat**	**Vitamin A**	**Vitamin C**	**Vitamin B1**	**Vitamin B2**	**Niacin**	**Pantothenic acid**	**Vitamin B6**	**Folic acid**	**Vitamin B12**	**Calcium**	**Iron**	**Magnesium**	**Zinc**
1	PLW			X										X	X		
	Adolescent girl			X										X	X		
	Child 9-11 months			O										X	X		O
2	PLW			X								X		X	X		
	Adolescent girl			X								X		X	X		
	Child 9-11 months			O										X	X		X
3	PLW			X								X	X	X	X		
	Adolescent girl			O								X		X	X		
	Child 9-11 months			O										X			X
4	PLW			X								X	X	X	X		
	Adolescent girl			X								X		X	X		
	Child 9-11 months													X	X		X
5	PLW			X								X		X	X		
	Adolescent girl			X								X		X	X		
	Child 9-11 months			O										X	X		X
6	PLW			X	X	X				O		X		X	X		
	Adolescent girl			X	X	X						X		X	X		
	Child 9-11 months				X									X	X		
7	PLW			X	X	X				O	X	X		X	X		
	Adolescent girl			X	X	X	O					X		X	X		
	Child 9-11 months			O	X		O					X		X			
8	PLW			X								X		X	X		
	Adolescent girl			X								X		X	X		
	Child 9-11 months			O										X	X		
9	PLW			X								X		X	X		
	Adolescent girl			X								X		X	X		
	Child 9-11 months													X	X		
10	PLW			X						X		X		X	X		
	Adolescent girl			X								O		X	X		
	Child 9-11 months			O										X	X		

It is important to note that this study focuses on access to nutrients in the first thousand days and therefore on limiting nutrients for three members in the household in particular: the lactating woman, the adolescent girl and the child under two. As expected, these household members were facing the highest constraints for meeting nutrient requirements. In the case of the man and the school-age child limiting nutrients are, in particular, fats and calcium across the 10 zones, vitamin A and/or folic acid for a reduced number of regions.

5.1.4.b Food sources of limiting nutrients

The cheapest food sources selected by the tool that provide these limiting nutrients are listed in table 2. In zones where food availability and food diversity is low, the software programme seeks to meet nutrient requirements

at an optimised cost. To do so, the software programme selects high quantities of the foods that are the cheapest source of a given nutrient. As an example, to meet calcium requirements for a household, as much as 1kg of dried fish per day is included in the SNUT diet.

Table 1 Sources of limiting nutrients for northern and southern Madagascar

Limiting Nutrients	Household member	Main cheapest source region North	Main cheapest source region South
Calcium	all	Small dried fish, green leaves	Small dried fish, green leaves
Iron	all	Fish, offal, legumes	Fish, offal, legumes
Folic Acid	all	legumes	Legumes, **cassava, maize**
Zinc	child under 2	Legumes, small fish	Legumes, small fish, **maize**

An outstanding difference in the source of limiting nutrients in the North compared to the South of Madagascar, is that communities living in the southern regions are able to cover a part of their limiting nutrients through commonly available staple foods. In the southern regions, cassava and maize are consumed every day in important quantities and therefore contribute to meeting folic acid and zinc requirements. As opposed to communities who live in the central and northern regions, consuming solely rice as staples, where limiting nutrients will have to be provided by other food sources. It should be noted that if cassava is shown to be a source of folic acid, cassava alone leads to serious micronutrient deficiencies.

This is an interesting finding, as Malagasy households in both northern and southern regions would always prefer to consume rice to any other staples. However in regions where rice cannot be produced due to unfavourable climate, such as the South of the country, communities mainly consume maize, cassava and sweet potato by default, therefore increasing their nutrient intake from staples(22).

It can be noted that some of the foods, included in the SNUT as a source of limiting nutrients, have been shown (from the availability analysis) to be rare in some zones, such as fish in the South of the country, increasing further the difficulty to meet requirements for these nutrients.

5.1.4.c The cost of the SNUT

On average, nationally, the cost of the SNUT is nearly 8,400 MGA (or 2.6 USD) from a total of 11 food items from 8 groups (table 3). Within the household, the adolescent girl has the most expensive diet with 2,600 MGA per day (or 0.81 USD) to cover high needs for growth and menses.

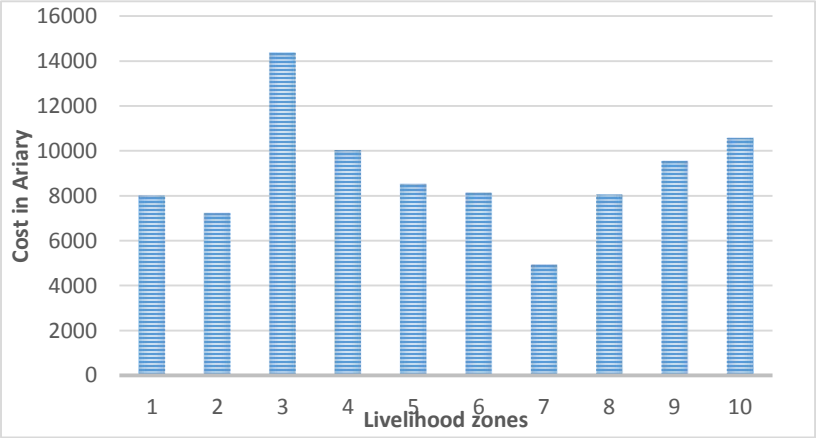
Table 2: National average cost of SNUT per day, per month and per year in Ariary

	Daily Cost	No. of Foods	Food Groups	Monthly Cost	Annual Cost
1 x man, 30-59 years, 65 kg, moderately active	1,976	7	6	59,280	711,360
1 x lactating woman, 30-59 years, 50 kg, moderately active	2,003	9	7	60,090	721,080
1 x female 14-15 years	**2,615**	**9**	**7**	**78,450**	**941,400**
1 x child (either sex) 6-7 years	1,201	7	6	36,030	432,360
1 x child (either sex) 9-11 months	602	7	5	18,060	216,720
Total	**8,397**	**12**	**8**	**251,910**	**3,022,920**

The lactating woman and the man require a similar cost to meet their nutrient requirements, however the woman requires a higher number of foods (9) from a higher number of food groups (7) to meet higher micronutrient needs. The adolescent girl requires a larger number of foods and food groups than the man to cover her needs, for the same reasons. In all the zones, the food item added in the SNUT diet of the lactating woman, the adolescent girl and the child 9 to 11 months is lung or liver from the offal food group, presenting a very high nutrient density. Even in regions where offals are expensive, the software programme selected small quantities of the cheapest offal to address the specific nutrient needs of this population group.

The average daily cost for the 9-11 months old child diet is low with 600 MGA (or 0.19 USD) per day. Indeed, the SNUT factors in 583g of breast milk daily, which provides over half of the recommended requirements for fat, a third of requirements for energy, vitamin A, vitamin C, vitamin B2 and pantothenic acid, between 20-30% of requirements for vitamin B1, niacin, vitamin B12 and calcium and 15-20% of requirements for protein, folic acid and zinc.

The average cost of the SNUT fluctuates from about 5,000 to 14,000 MGA per day (or 1.55 to 4.35 USD per day). However, in most regions, the cost varies between 7,000 and 10,000 MGA per day (or 2.20 to 3.10 USD). The variation can be due to specificities of the markets selected in the sample but also due to the availability of nutrient dense food at a cheap price in the market. For instance, in the Eastern zone, costs for the small fish food item are higher than in other regions. Calcium requirements are mainly covered by a combination of green leaves and small fish. This explains the

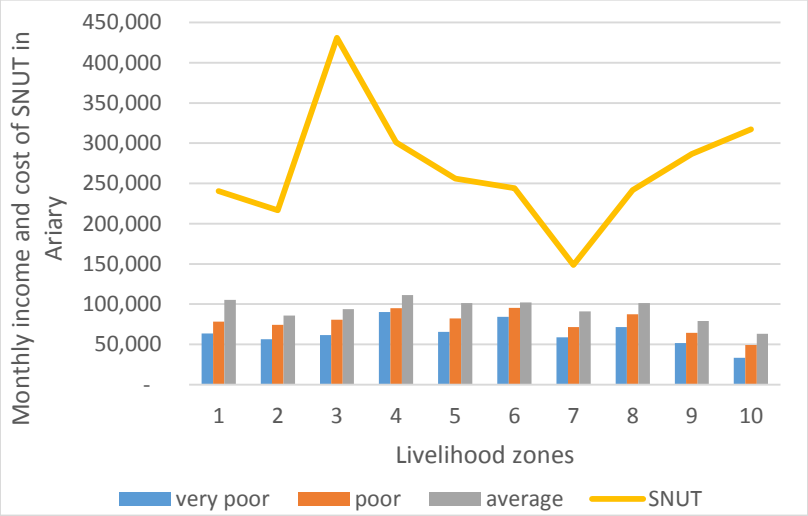


Graph 5: Daily cost of SNUT per zone in Ariary

higher cost of the overall SNUT diet in the zone, increased by the need to cover calcium requirements.

5.1.5 Affordability of the SNUT

5.1.5.a Affordability of the SNUT per zone



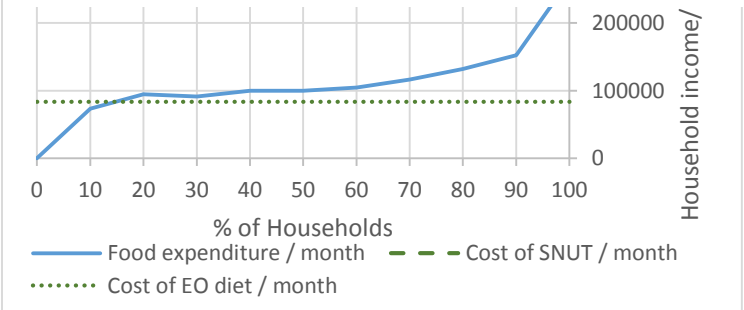
Graph 6: monthly income per poorer quintiles and monthly cost of SNUT for each region

The cost of the SNUT diet was compared with households' income data to evaluate the proportion of households that can afford the theoretical cheapest balanced diet for each zone. Establishing accurate levels of household income based on survey assessments is a challenge, therefore household total expenditure was used as a proxy for household income. Poor households usually spend close to 75% of their total expenditure on food. The same rate was applied to total expenditure data in the affordability analysis. Across all the zone, very poor, poor, or even average income households cannot afford the SNUT (graph 6). This outstandingly low affordability is expected in the context of high poverty and extreme poverty, specific to Madagascar.

5.1.5.b Affordability of the SNUT and energy only diet

For the purpose of understanding further the added costs that meeting nutrient needs represents for households, the affordability of the SNUT is compared to the affordability of the energy only (EO) diet. The EO diet is the combination of foods available in the local market that only meets the energy requirements. Zone 6 was chosen for this comparison as it is the most populated out of the 10 zones.

Graph 7: Distribution of monthly food expenditure in the population per wealth deciles and comparison of affordability of EO and SNUT diets in zone 6 (in MGA)

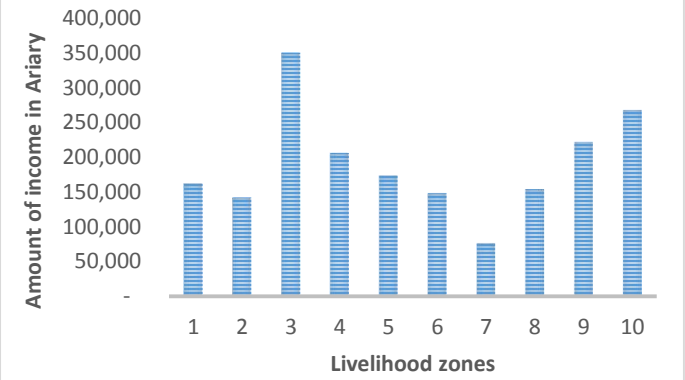


In graph 7, except for the poorest decile, the EO diet is affordable by households for a monthly cost of 83,500 MGA (or 26 USD). It is mainly composed of maize or cassava. On the other hand, except for the richest decile, the SNUT diet is not affordable by households which is three times more expensive than the EO diet for a monthly cost of 245,000 MGA (or 77 USD).

5.1.5.c Financial gap to afford the SNUT

Excluding the 2 extreme values of zones 3 and 7, the financial gap per month for poor households to afford the SNUT varies between 150,000 to 250,000 MGA per month or 5,000 to 11,500 MGA per day. In USD, 46.90 to 78.10 per month or 1.55 to 3.60 per day (graph 7).

Graph 8: additional income needed per month for poor households to afford the SNUT per region in Ariary

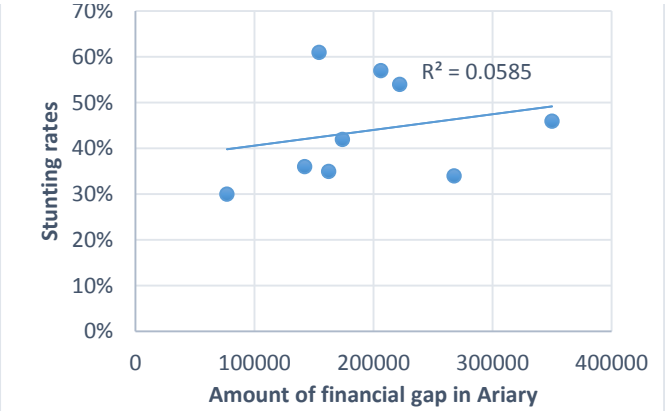


'Economic access' to nutrients constitutes an important barrier for a household's adequate nutrition, in all the regions. In a country where 90% of the population lives under 2 dollars - or 6,500 MGA - a day, generalized poverty understandably limits the capacity of households to meet their nutrient requirements.

5.1.5.d Affordability of the SNUT and stunting

Similar to food availability and diversity, SNUT affordability and stunting rates in children under five are strongly correlated. The zones where households have a larger financial gap to access nutrients are the zones that show higher rates of stunting in children (graph 8).

Graph 9: correlation between financial gap to afford the SNUT and stunting rates



5.1.6 Feeding practices and taboos

Current feeding practices in Madagascar were reviewed to assess how cultural factors influence nutrient intake of population groups vulnerable to malnutrition.

Text box 2: Tambavy, a barrier to exclusive breastfeeding

Tambavy is a traditional preparation of leaves infused in water. Sugar or rice water can be added in some cases. Tambavy is believed to have ancestral pediatric virtues and to serve as a link between the physical and spiritual development. It is regularly consumed by the mother and child as a drink or applied on the body. Parents believe regular consumption before the age of 6 months supports good physical development(28).

In an environment where availability of nutrient-dense foods is low and at a higher cost, breast milk stands out as an indispensable, cheap and safe source of nutrients. However, according to a survey from 2012, only 42 percent of children under six months are exclusively breastfed(8), in line with WHO recommendations. Few women know that feeding other foods or liquids under the age of 6 months is inadequate practice. The persistent beliefs that breast milk has a poor nutritional value encourages the spreading of harmful practices in infant and young child feeding(23). The consumption of *tambavy* (infusion) is part of these harmful practices (text box 2). In women, poor practices include consumption of tambavy during pregnancy and deliberate dietary restrictions. In addition, food taboos or *fady* are common in Madagascar. Fady prohibit the pregnant woman or the mother to eat certain meats, eggs, certain legumes or certain vegetables.

The SNUT diet factors in 583g of breast milk per day for a 9-11 months old child, providing a substantial part of the daily nutrient requirements and bringing down the cost for complementary food to only 0.19 USD. The same survey mentioned above revealed however that only 25 percent of children under two receive a minimum acceptable diet in rural areas(8). Rice pureed in water is the preferred weaning foods for infants from the age of 6 months. It is believed to bring strength to young children(23). Despite presenting a very low nutrient density, the quality of the water used for such preparations raises food safety concerns.

The review therefore suggests that current feeding practices in the first thousand days, influenced by cultural belief, further prevent vulnerable groups from adequate nutrient intake.

5.2 Key findings from the study

As demonstrated, the following key findings were established, aligned with the study's objectives.

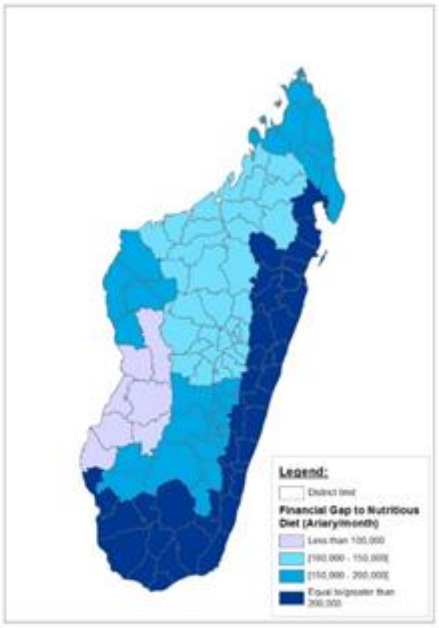
- Except for the regions near the capital city, the country presents a very low availability of nutrient-dense foods with 25 to 45 non-staple food items in local markets. Half of the non-staple food items are from animal sources. Low availability of nutrient dense-foods constitutes a barrier for households to meet their nutrient requirements. In this context, meeting nutrient requirements is particularly challenging for women, adolescent girls and children under two who all have higher and more specific nutrient needs.
- As expected, a strong correlation could be established between low availability of nutrient-dense foods and high rates of stunting in children under five. In the zones where animal-source foods are the least available, zones 3 and 8, the prevalence of stunting is critically high, with respectively 46 and 61 percent.
- Fat, folic acid, calcium and iron are limiting nutrients for women, adolescent girls and children under two in nearly all the regions. Zinc is a limiting nutrient for children under two in the northern regions of the country. Vitamin C and A are additional limiting nutrients for the adolescent girl and the lactating woman in the central regions. The requirements of these nutrients are the most difficult to meet from foods available in the market. Foods providing these nutrients are available in the local markets but these are expensive such as dried fish, oil and offal. They are therefore likely to be deficient in the current diet.
- Although this study specifically aims to establish what would be the cheapest locally available combination of foods that will meet households' requirements, it gives an indication of which foods found in the local market are the least expensive and most nutritious. In rural Madagascar, the majority of essential micronutrients are provided by vegetables, beans, liver or lung, green leaves, dried fish or insects, cassava or maize and oil. Green leaves and dried fish or insects provide most of calcium requirements. Beans and cassava provide folic acid, vitamin A and C are provided by pumpkin and oil, vitamin B12 by fish or insects, iron by lungs or liver and beans, zinc is provided by dried fish or insects and beans.
- On average, nationally, the cost of the SNUT is nearly 8,400 MGA (or 2.6 USD). A total of 12 food items from 8 groups are needed to cover a household's nutrient requirements from locally available foods. PLW and adolescent girls require an addition of liver or lung from the offal food group to cover their high and specific nutrient needs. Children under two receive a large amount of nutrients through breast milk, however they still require 7 food items from 5 food groups daily to cover their nutritional needs, including from animal sources.
- The SNUT diet is three times more expensive than an energy only diet, i.e. the cost to meeting recommended energy, protein, fat and micronutrient requirements is three times the cost of meeting energy requirements only. If most households can afford an EO diet daily, mainly composed of staple

foods, the cost of the SNUT diet is out of reach for the very poor, poor and average rural households across the country.

- Based on current livelihoods and income, the financial gap to the cheapest balanced combination of foods is 5,000 to 11,500 MGA a month.
- Stunting in children under five is correlated to the affordability of the SNUT, the rates are higher in the zones where households have a larger financial gap to afford nutrients. The ten zones can be classified as below (map 3):

  - Financial gap inferior to 100,000 MGA: zone 7
  - Financial gap from 100,000 to 150,000 MGA: zones 2 and 6
  - Financial gap from 150,000 to 200,000 MGA: zones 1, 5 and 8
  - Financial gap superior to 200,000 MGA: zones 3, 4, 9 and 10

- Feeding practices and taboos, influenced by cultural beliefs, further prevent adequate nutrient intake in the first thousand days.



Map 1: Financial gap to nutritious diet SNUT per region per month in Ariary

6. Discussion

This section will discuss the justification for generalizing the study findings in the rural areas in the country and how these results on nutrient access in Madagascar relate to current evidence. The findings will also be linked to the conceptual framework of malnutrition to identify additional factors that influence nutrient intake in this context.

6.1 Justification for extrapolation

One of the main assumptions of the CoD methodology lies in considering that each livelihood zone is homogenous. Within each zone, particularly in the littoral zones, livelihoods and access to foods may differ whether communities live along the coast or inland.

The 60 markets selected for the survey cover a large proportion of the rural population, an average of 15,000 people per market, or about 900,000 people from a total of 17.6 million people living in rural areas. In each region, the markets selected therefore covered more than 5 percent of the population.

In each zone, the sampling method of primary, secondary and village markets required the selection of markets spread across the entire zone (map 3). This method aimed to reduce bias from specific market dynamics or suppliers by widening the location of markets included in the study.
The low price variation within each zone appears to confirm that the sample size and composition is representative of each zone. Moreover, the comparison of the prices collected in the 60 markets of the sample with the prices collected in 120 markets, as part of the national price monitoring system, showed minimal variation.

Based on the above factors, although some variation within a livelihood zone should be considered, with coverage of a large part of the population and decisions in market sampling taken during study design to reduce sampling bias, this study can be considered representative. Results per zone can be extrapolated to the entire zone.

6.2 Access to nutrients

6.2.1 The composition of the SNUT diet and food consumption

According to a 2010 food consumption survey, the traditional Malagasy diet is based on rice (6.2 times per week), vegetables (4.4 times per week) and tubers (cassava 3.9 times per week), with rare consumption of plant and

animal proteins (1 to 2.3 times per week). Only 22 percent of the population actually consumed an acceptable diet in terms of diet diversity(22).

Although the software programme allows for the application of parameters to constrain the software in generating culturally acceptable diets, for the purpose of optimization, and particularly in areas with low food availability and diversity, the quantities selected by the software for certain foods may not be realistically consumable. For example, in the Melaky region, livelihood zone 5, the SNUT diet was composed of rice, cassava, beans, peas, pumpkin, sweet potato leaves, small fish and oil. This combination of foods could very well constitute a local diet. However, the software selected 4kg of sweet potato leaves as it is a cheap source of calcium, and the cheaper option to cover the calcium requirements. The recommendation for a ration of 1 kg of dried fish for a daily household ration is similarly unrealistic. To this day, it has not been assessed how the costing of realistic diets would affect results.

The SNUT diet is theoretical and the study does not imply that households actually consume the SNUT diet. However, the low frequency of consumption of nutrient-dense foods and the high consumption of staple foods measured in actual dietary habits could partly be explained by the barriers from food availability and affordability to reaching a nutritious diet, outlined in this study.

6.2.2 Critical assessment of household size and composition

6.2.2.a Arbitrary selection

The standard household composition in this analysis is an arbitrary selection of individuals. This study work aimed to identify context-specific strategies for improving feeding practices with an emphasis on increasing access to nutrients, especially during the critical period of the first thousand days. In this way, pregnant and lactating women, adolescent girls and children under two constitute the specific target group for this study. Defining a typical household size and composition was a necessary simplification.

6.2.2b Effect of household size on results

The typical household size in this analysis was defined based on the latest national household survey(8). Although the national average household size is about 5 members in rural area, it is important to note that this number varies from 3.9 to 5.1 per zone. Based on regional average, the cost of the SNUT diet could be overestimated for the zones 1,2,3,4 and 7. However, when looking at the household size per wealth quintile, the household size is significantly higher in poorer groups than the average per zone. As such, the typical household size for the 2 poorest quintiles in most of the zones - 7 zones

out of 10 – is above 5.5. The cost of meeting nutrient requirements in most of the poorer households would then be higher than the costs estimated in this analysis.

Table 3: Household size variation per zone

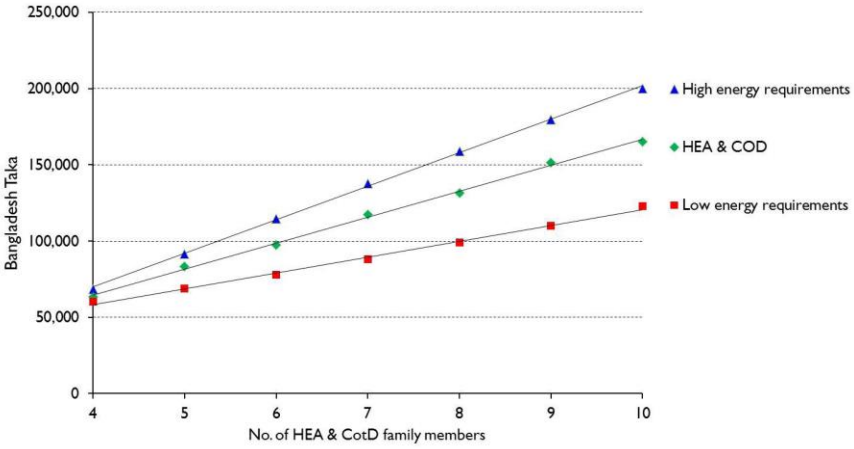
	Poorest				Richest	
Zone	1 Quintile	2 Quintile	3 Quintile	4 Quintile	5 Quintile	Average
1	4.9	4.1	3.9	4.0	3.1	**4.0**
2	**5.5**	4.7	4.8	3.9	3.5	**4.5**
3	5.0	4.3	4.1	3.3	2.8	**3.9**
4	5.5	4.8	3.9	3.5	3.2	**4.2**
5	5.3	**5.6**	5.1	4.7	3.5	**4.8**
6	**5.7**	5.2	4.9	4.4	3.8	**4.8**
7	**5.7**	4.7	3.9	4.1	3.2	**4.3**
8	**5.8**	**5.6**	5.1	5.0	4.0	**5.1**
9	**6.3**	**6.0**	5.2	4.4	3.5	**5.1**
10	**5.7**	**5.6**	4.7	5.2	3.8	**5.0**

Considering that the SNUT diet for a household of 5 members is unaffordable for the poorest quintiles, this only suggests that poor households may face deficiencies in a larger number of nutrients than the limiting nutrients identified through this study.

6.2.2c Additional analysis

For further analysis, the cost of the SNUT could be calculated taking the lightest, least active adults and smallest children to create a household of 5 individuals and taking the heaviest, most active adults and largest children to create a household of 5 individuals. In this way, results would give a range in values, useful to assess potential range in cost of the SNUT.

Graph 10: variation of SNUT cost for high and low energy requirements. Source: Save the Children UK



Bangladesh provides an example. A CoD analysis measured the range in energy requirements and subsequent cost of SNUT for households of 4 to 10 individuals. The range in cost of SNUT increases proportionally with the number of individuals in a household (graph 8)(24). This example is also applicable to other countries. In Madagascar, the size and composition of rural households vary according to livelihood zones and according to wealth groups (see table 4). Investigating further how the size and composition of the

household affects the cost of the SNUT would be useful to tailor interventions accordingly.

6.2.3 Influence of food availability and affordability

This study established that food availability and affordability are both hampering vulnerable groups from meeting their nutrient requirements. In the context of Madagascar, a nutritious diet was always possible from locally available foods in all the zones. In other contexts, for instance in Ghana, the CoD analysis reported an incapacity to generate SNUTs from the foods available in the market in specific livelihood zones from the North of the country(25).

Availability of animal source-foods at a low price is shown to have an important influence on nutrition outcomes. Indeed, the zones with lower food availability of animal-source foods record critically high rates of stunting in children. If a diverse diet - composed of 8 food groups in our study - is necessary to meet nutrient requirements, animal-source foods are essential to PLW, adolescent girls and children under two, as they present a high density in essential nutrients for growth (vitamin A, vitamin B12, riboflavin, calcium, iron and zinc). Meeting these requirements from plant-source foods alone is challenging for these population groups with higher and more specific nutrient needs (26).

The results of SNUT affordability in Madagascar are outstandingly low. The cost of the SNUT being three times higher than the diet that poor households can afford seems an insurmountable, and therefore highly restrictive, barrier to nutrient access. For example, through the same methodology in El Salvador or Sri Lanka(27), the SNUT was affordable by respectively 63 percent and 68 percent of the population. In Madagascar, households' income is a major determinant of adequate nutrient intake. A survey from 2012 measured that 16 percent of children under two from the poorest wealth quintile received a minimum acceptable diet against 46 percent in the richest wealth quintile.

6.3 Additional factors influencing nutrient access

When linking the findings of this study to the conceptual framework of malnutrition, it appears that additional factors, in particular the basic and underlying causes of malnutrition, also influence nutrient intake. The most influential factors and how they impact nutrient intake is analysed below.

6.3.1 Seasonality

In Madagascar, very poor and poor households do not own land, rely on local market to obtain their food and are therefore particularly vulnerable to rising food prices. The study covered the month of August, which is the end of harvest in most of the regions, a time of year when food availability and prices are favourable.

Results may have also have been influenced by some contextual events from 2014. Climatic shocks during 2014 planting season – both drought and flooding – have affected the 2015 harvest, inducing crop failure (21). It was estimated through a crop assessment that rice, maize and cassava production was reduced by 6, 10 and 9 percent respectively compared to the average of the last five years. This resulted in rising prices for staples from August 2014 to August 2015. The cost of the SNUT may be higher in 2015 than in a 'normal' year.

Because food availability and prices are likely to vary in the year, and at times form year to year, results are only applicable to the period covered.

6.3.2 Own production

Agriculture is the main livelihood in rural Madagascar. The majority of the rural population is composed of smallholder farmers, 70 percent cultivating land surfaces of less than 1.2 hectares and 50 percent cultivating land surfaces of less than 1 hectare. Because the food production is reduced and part of the crops are sold to cover other needs, some 65% of the food consumed by an average household in a year is purchased from the market.

Vulnerable households cumulate additional difficulties such as no land ownership, poor availability of seeds and tools or a lack of labour force in the household(22). These factors affect their capacity to self-sustain their food needs. The proportion of vegetables and staples consumed by poor households coming from own-production in the month of August is not known accurately but it can be considered that poor households may be able to cover a small part of their staple and vegetable needs, in any case less than the 35% that average households manage (which is taken into account in the SNUT analysis).

6.3.3 Poorer food quality

The analysis highlights that fats, folic acid, iron, calcium and zinc are amongst the main limiting nutrients of the SNUT diet. These calculations are based on the nutrition value of foods from the food list. It is important to note that food

nutrition composition tables are established from average quality foods. When poor and very poor households purchase foods, within each food group, they usually choose the lower quality, cheaper option(14). For instance foods that have been stored for a long time, or foods that are partially spoilt. These foods would supposedly present a lower micronutrient content compared to the average nutritional values in the composition tables used by the software. This constitutes an additional difficulty for the poorest households to meet nutrient requirements within their affordability capacity.

6.3.4 Intra-household distribution

The sharing of foods within the household influences the nutrient intake of PLW, adolescent girls and children under two. In particular, this study has emphasized that animal-source foods are essential to meet higher and more specific nutrient needs from these groups. Although the distribution of animal-source foods in the household is not well established in Madagascar, surveys show that women have limited power over decisions related to intra-household distribution to her and her children(18).

In households that cannot afford the SNUT, unequitable sharing of nutrient-dense foods further increase risks for nutrient deficiencies in PLW, adolescent girls and children under two than the limiting nutrients identified in this study. For the same reasons, in households that can afford the SNUT, it is not prudent to conclude that nutrient needs for these groups are met.

6.3.5 Demand for adequate nutrient intake

In Madagascar, the level of education is very low in rural areas - illiteracy can be as high as 70 percent (8). Beyond the weak decision-making power of women over the use of the household's resources, how nutrient needs are understood in rural households could affect negatively the demand for adequate nutrient intake. From a survey undertaken in 2012, the level of education of mothers influences the proportion of children under two receiving a minimum acceptable diet (16 percent for mothers with no education, 45 percent for the most educated).

7. Conclusion- recommendations

7.1 Main conclusions

Optimal nutrition in the first thousand days of life requires the needs of 40 nutrients to be covered on a daily basis for PLW, adolescent girls and children under two. By estimating the cheapest theoretical nutritious, yet culturally acceptable, diet and its cost, this study demonstrates that most Malagasy households are confronted with a number of barriers when meeting their nutrient requirements.

Most rural markets offer a very low diversity and availability of nutrient-dense foods. This includes low availability of essential animal-source foods. In addition, generalized poverty hampers households' capacity to afford the cheapest combination of foods covering the nutrient needs of a typical household. In this environment, PLW, adolescent girls and children under-two are the most vulnerable to malnutrition due to their higher and specific nutrient needs.

Low nutrient availability and affordability negatively impact nutritional status in the first thousand days. This was illustrated by correlations found between stunting in children under five and a) low nutrient-dense food availability in the market, and b) households' low capacity to afford the SNUT. Compared to similar analysis from other countries, affordability of nutrients is outstandingly low and seems to be the main barrier to nutrient access in Madagascar.

Low nutrient access contributes significantly to stunting but is not the only factor that influences nutritional status. Additional factors contribute to inadequate nutrient intake and ultimately nutritional status as established in the conceptual framework of malnutrition. Some of these factors are highly influential in the context of Madagascar, such as traditional feeding practices and food taboos, high illiteracy or the low status of women.

Although the determinants of malnutrition are multisectorial, adequate nutrient intake is a necessary precondition to improved nutrition outcomes. To support the reduction of stunting in Madagascar, the findings from this study provide recommendations for the development of strategies with the aim to improve nutrient intake per vulnerable group, per nutrient and per zone.

More specifically, and according to the set of evidence-based interventions from the Lancet (2013), the recommendations are classified into 'nutrition-specific', 'nutrition-sensitive' and 'building an enabling environment'. These

interventions address, respectively, immediate, underlying and basic causes of malnutrition. All recommendations are formulated and based on results from the post-harvest season and should be adjusted for the lean season through a further analysis.

These interventions can then be implemented along with complementary health, water, sanitation and hygiene (WASH) and education interventions. However, this study demonstrates that interventions that would only seek to improve health, education and WASH outcomes would fail to contribute to better nutrition outcomes because they do not contribute to an increased nutrient intake.

7.2 Horizon 2030: the global goals

In September 2015, the United Nations member states adopted a set of seventeen goals to "end poverty, protect the planet, and ensure prosperity for all" as part of a new sustainable development agenda. Each goal has specific targets to be achieved in 2030.

This new agenda sets a global framework for governments and their partners to focus development efforts over the next 15 years. From the seventeen sustainable development goals, objective 2 seeks to "end hunger, achieve food security and improved nutrition and promote sustainable agriculture". This goal constitutes an achievement from the millennium development goals as nutrition and food security are now clearly formulated as a development priority and the goal recognizes the crucial role of food strategies in improving nutrition.

The findings of this study will help to contribute to this agenda. They provide national and development stakeholders with useful information for policy dialogue with the prospect to significantly improve the food security and nutrition policy development towards the global goals.

7.3 Recommendations for policy and programme development

From the findings of this study, the Lancet 2013 'nutrition-specific', 'nutrition-sensitive' and 'building an enabling environment' interventions are reviewed to indicate those that are particularly relevant and a priority for Madagascar.

7.3.1 Nutrition-specific interventions

The current National Nutrition Action Plan (PNAN II) for the period 2012-2015 is used as a reference framework for the stakeholders in relation to planned

nutrition-specific measures in Madagascar. The below recommendations seek to strengthen adequate nutrient intake, per zone and per specific vulnerable group in the first thousand days.

7.3.1.a Maternal dietary supplementation for pregnant and lactating women

- Use multiple micronutrient tablets during pregnancy and lactation. The study suggests that multiple micronutrient tablets would be better adapted to fill the nutrient gaps in this target group across all zones, as a replacement for iron/folic acid only supplementation. Folic acid and iron supplementation, as is practice in Madagascar, fails to fully cover PLW high micronutrient needs. From this study, other limiting nutrients include calcium, vitamin A, C, B1, B5, B6 and B12.
- Provide maternal dietary supplementation in areas where stunting is particularly high or where access to animal-source foods is low and/or where levels of income are low - all zones except zone 2 and 7 from the results. Small quantity lipid-based nutrient supplement (LNS) could be provided to PLW to fill fats, micronutrients and animal-source amino acids gaps. Fortified flour (Supercereal) and oil could be provided as an alternative in the same regions during the lean season to fill additional protein and energy gaps.

7.3.1.b Adolescent health and preconception nutrition for adolescent girls

- Because of the sexual behavior of adolescent girls in Madagascar, as stated in the background section, special attention to nutrient intake in this group is needed prior to and during pregnancy.
- Adolescent health and preconception nutrition is only implemented in urban areas in Madagascar. As outlined by the results, these services should be extended in rural areas where needs for this group are high in all the zones. For example through school health programmes or through rural youth centers to reach school drop-outs.
- Specifically for preconception nutrition, the use of multiple micronutrient tablets would cover the limiting nutrients for this group include calcium, vitamin A, C, B1, B5, B6, and B12.

7.3.1.c Breastfeeding and supplementation of complementary feeding

Behavior Change Communication (BCC) programmes on IYCF are currently provided routinely through community health and nutrition workers in all of Madagascar. They are designed around 21 themes following the life cycle.

- Continue and strengthen BCC through the life cycle approach aimed at increasing men and women's understanding of the importance of nutrient

intake in the first thousand days. From this study, the following themes should be prioritized.

For infants from 0 to 6 months:

- Strengthen promotion of exclusive breastfeeding. The study results provide additional rationale for the promotion of exclusive breastfeeding by demonstrating both economic and health benefits of such a practice to the households and the child.

For children 6 to 23 months:

- Provide nutrient-dense foods to supplement complementary feeding from 6 to 23 months. In regions where fats are limiting nutrients, where animal-source foods have low availability and where stunting is high, a small quantity LNS would be advisable – i.e. in zones 1, 2, 3, 4, 5, 8 and 10 from our results.
- Promote breastfeeding until the age of two as the cheapest, healthiest and safest source of nutrients for this age group.
- As demonstrated in the study, standalone BCC related to complementary feeding and nutrition of PLW from local foods are unlikely to have an impact unless issues of food availability and affordability are being addressed.

7.3.1.d Micronutrient supplementation and fortification

- Continue to provide vitamin A supplementation is provided biannually in children under five through campaigns in all the zones and should be continued.
- Consider home fortification through micronutrient powders. In zones 6, 7 and 9, where there are more limiting nutrients, micronutrient powders are a relevant strategy to fill the micronutrient gaps through home fortification in all the vulnerable groups, as long as complementary interventions ensure access to a balanced diet in macronutrients (especially fats).
- Increase the production and availability on the markets of fortified foods to address the low availability of nutrient-dense foods. Fortification of expensive foods may not seem relevant, unless subsidized to become affordable. Staples (rice, cassava, maize, wheat) are the preferred foods for fortification as they are the cheapest most widely consumed foods.
- Follow global recommendations to only allow vitamin A fortified oil on the market.
- The limiting nutrients identified in this study (calcium, zinc, folic acid, iron, vitamin C, A, B1, B5, B6, B12) should be prioritized for fortification in line with international standards (Codex).
- Dialogue with the private sector and governmental counterparts should be initiated to sell fortified foods at low cost or consider selling at subsidised price, for poor and very poor households to be able to purchase these

fortified foods. Alternatively, vouchers to increase access to fortified foods could be provided to vulnerable population groups.

7.3.2 Nutrition-sensitive interventions

7.3.2.a Social safety nets

To this date, a national social protection policy has only just been drafted and requires to be implemented to support the Malagasy population. The findings of this study can feed into the policy and technically assist the government when taking into account nutrition considerations in social protection schemes.

- The key findings of this study provide indication for better targeting of social safety nets to improve nutrition outcomes in vulnerable groups. Poor and very poor households with PLW, adolescent girls and children under two should be targeted in priority for social transfers in all the zones. Indeed, the study outlines that with their current levels of income, nutritious diets are three times more expensive than the diets they can afford for households composed of five members. For larger households, unaffordability of nutritious diets is even higher.
- The findings also provide a useful indication to help define the nature of social transfers needed to contribute to better nutrition outcomes in vulnerable groups. The provision of cash, vouchers or in-kind social transfers are all adequate strategies to fill nutrient gaps, under the condition that the amount of cash transfer is high enough to cover the financial gap to afford the SNUT.
- From the study, the appropriate daily amount of cash transfers would be 3,300 MGA (zone 7), 5,000 MGA (zone 2 and 6), 6,700 MGA (zone 1, 5 and 8), 11,500 MGA (zone 3, 4, 9 and 10) for households of five members. For larger households, the daily amount of cash should be increased. Complementary to cash transfers, BCC on IYCF and women/adolescent girls' nutrition is necessary to educate households on combinations of foods from the market and portions needed to obtain a nutritious diet.
- Vouchers would be relevant to provide households with specific nutrient-dense foods, including foods from animal sources and fortified foods. Results from the study have revealed that beans, dried fish or insects, liver or lung, oil, green leafy vegetables, cassava or maize and pumpkin are important and usually available sources of nutrients. Results from this study can be used to determine the quantities that the voucher would provide for each of the nutrient-dense foods for a household per region, per population group.
- In-kind transfers are particularly appropriate in areas where food availability on the market is particularly low (and where cash and voucher modalities would not be effective or would risk inflation i.e. in zones 1, 2,

3, 4, 5, 8 and 10 from the results). In-kind transfers should be based on the recommendations provided in the 'nutrition-specific' section per vulnerable group, per nutrient and per zone.

7.3.2.b Agriculture and food security

The analysis provides evidence that food availability should increase in rural markets, especially for nutrient dense foods at a cost affordable to households. Simultaneously, to address the economic barriers to nutrients, the earning potential of very poor and poor households needs to be increased by developing livelihood opportunities so that households can access foods in a sustainable manner. Indeed, the results have highlighted that current consumption patterns are unlikely to change unless income is increased and/or availability of nutrient-dense foods increases.

- Currently the main labour opportunities in rural areas are based on casual agriculture, which is very vulnerable to shocks such as drought and flooding. Recurrent shocks can greatly affect the outcomes of such labour on which many of the poor and very poor depend, limiting their income levels and their ability to purchase nutritious food.
- Develop interventions aiming to increase crop production and diversification to increase food availability and reduce food prices. For instance, support with tools, improved seeds, infrastructure that reduces vulnerability to shocks, provision of land to vulnerable households.
- Develop interventions aiming to improve the nutrient density of locally available foods. For instance, fortification of locally produced foods, use of bio fortified seeds, promotion of home gardens, and promotion of auto-consumption.
- Develop interventions aiming to increase income in agriculture labour. For instance, through the development of improved value chains.
- Diversify income generating activities to mitigate risks related to threats to agricultural labour. Market and other livelihood assessments are therefore required to identify livelihoods that are viable. If opportunities are limited, investments would be needed to build community assets that could support the development of sustainable livelihoods.
- As a complement, BCC on IYCF and women/adolescent girls' nutrition should be mainstreamed and target both men and women in all the regions. Although the PNAN II mainstreams nutrition-sensitive approaches in the agriculture sector, integration of nutrition considerations in agricultural plans and implementation needs to be supported.

7.3.3 Building an enabling environment

7.3.3.a Policy development

Evidence from this study supports the national understanding of determinants of malnutrition. Results can influence the national nutrition agenda by highlighting the impact of economic factors such as high food prices on a household's access to a nutritious diet, or advocating for the provision of supplementation for vulnerable groups.

The country is currently initiating the development of the 2016-2020 national nutrition action plan – a process led by the national office for nutrition (ONN). The findings of this study and recommendations can be used by the ONN and their partners to feed into the new national nutrition plan. Findings will orientate nutrition-specific interventions as well as advise on the integration of nutrition considerations in other sectorial action plans.

- The study provides evidence that there is a need to increase food availability and affordability in rural areas and provides relevant recommendations. The recommendations can support the prioritization of interventions, where the most impact can be made. Of these the case for food fortification of staple as well as micronutrient supplementation can be best argued.
- In addition, the findings help to prioritize geographical areas and population groups and indicate the nature of priority interventions for other nutrition-sensitive approaches that aim to contribute to improved nutrition outcomes. Notably, social protection and livelihood intervention.
- Evidence generated by this study will be disseminated to the broader stakeholder community and donors to seek buy-in, share lessons learnt and collaborate on specific themes of intervention across sectors.
- With regards to food fortification, the study findings could support the development and roll out of a National Fortification Strategy. Food fortification requires considerable investment. Such a strategy would lay the foundations for the government and partners to advocate for increased resources and the enforcement of existing legislation on food fortification.
- The strategy could be elaborated with the participation of the Scaling Up Nutrition (SUN) Business Network and seek to harmonise efforts from the private sector for the local production of nutrient-dense foods.

7.3.3.b Advocacy strategy and key messages

Concrete advocacy messaging and actions can be formulated from the study findings, around those identified areas where the most impact can be made to reduce malnutrition. In particular, the issue of staple fortification in Madagascar emerges as a critical area of work for nutrition stakeholders.

Therefore, some key advocacy messages, based on the research work, are listed below to directly support this area of work over the next years:

- In Madagascar, food diversity is limited and significantly depends on the local area; therefore, large-scale food fortification of locally produced foods represents a powerful means of reducing micronutrient deficiencies among large segments of the population. While some efforts have been made by government in partnering with private sector and other stakeholders, it remains a largely untapped area with potential to impact the status of nutrition.
- The findings of this study confirm the need to strengthen nutrition sensitive interventions and integrate nutrition in sectorial policies as nutrition specific interventions alone cannot address malnutrition. By adhering to the Scaling Up Nutrition (SUN) movement in 2012, the country laid the foundations for multi stakeholder coordination in nutrition. The implementation of the SUN coordination and partnership mechanisms should be accelerated.
- The study brings evidence to support the development of food fortification policies, scaling up public-private partnerships and advocating for policy implementation in view of realizing successful fortification efforts in Madagascar.

7.3.3.c Further research

In the course of this study, a number of areas for complementary research have been identified:

- Completing this study with additional data collection during the lean season would provide an insight to seasonal change - an important issue across the country - and subsequent influence on nutrient availability and affordability. A seasonal analysis would directly support policy and programming partners to better target their interventions according to changing needs of the Malagasy population, where and when it will have the greatest impact. For this, a food list of about 60 food items would be sufficient as food diversity is lower in the lean season than in August.
- Differentiation in the cost of a SNUT taking into account household size and composition.
- Consumption patterns from own production particularly in vulnerable households.
- A review of evidence and case-studies on local production of complementary foods and rural fortification approaches. This would be needed to identify effective and viable options for Madagascar.

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Nora Hobbs, Author

Annex 1: Details on regions covered by each zone and agro-ecological specifics

Livelihood zone	Administrative regions	Agro ecological specifics
LZ01	Sava - Diana	Rice, tropical fruit
LZ02	Boeny - Sofia	Rice and vanilla
LZ03	Atsinanana	Humid, rice paddies, tropical fruit
LZ04	Alaotra Mangoro	Rice and market gardening
LZ05	Melaky	Rice plains, pulses
LZ06	Analamanga, Itasy, Vakinakaratra	Antananarivo Rural, rice, market gardening, fruit
LZ07	Menabe	Rice plains, pulses
LZ08	Amoron'I Mania, Haute Matsiatra, Ihorombe	Highlands, rice paddies, market gardening, apples, pears, plums
LZ09	Anosy, Atsimo Atsinanana	Humid, rice paddies, tropical fruit
LZ10	Atsimo Adrefana, Androy	Semi-arid, maize, cassava, sweet potato, pulses, cattle herding

Source: World Food Programme, Rapport special d'evaluation de la securite alimentaire a Madagascar. 2013

Annex 2: Market sampling, definition of food lists, client selection for interviews

Food price data was collected from a purposive sample of 6 villages or towns within each assessment zone.

The selection of markets for data collection is a two-stage process:

1. The villages or towns representative of the livelihood zone. This selection was conducted with a resource person with a good knowledge of the local area.
2. The markets where the poorest households purchase their food. In each selected village, a group of local authorities and local leaders was formed and consulted to draw an exhaustive list and map all the markets in the village. They identified the poorest groups in the community and indicated the markets where the poorest households purchase their food. Depending on the number of markets identified either all sites or a representative sample of sites should then be selected for survey. Informal networks of food purchase such as exchange of livestock was taken into account.

Once the location was selected, the national guide of local foods by regions was used to list all foods available locally. This list was presented to the village group of leaders, revised according to their specific context and recorded. Breast milk is included as it is the cheapest source of energy and nutrient for a 6-23 months old child. Breastfeeding practices are included in the software.

Food prices was collected by interviewing enough shop keepers and local traders to fill in 4 market survey sheets. At the market, the shop keepers were visited one by one, informed on the study's objectives, informed consent to participate asked and interviewed until the 4 market survey sheets are filled in.

After the market survey was completed, 4 men or women who purchase their food from the market, were selected to participate in an interview on their dietary habits. The inclusion criteria was to be a client in the market. Women were preferred as directly involved with the preparation of meals for the household.

Annex 3: Procedures for data collection

The 10 zones were covered by 5 teams. Each team was composed by 4 enumerators and 1 supervisor. In each town or village, each enumerator filled in one survey sheet so that 4 survey sheets were collected in each town or village. Consequently, a market was surveyed in one day.

In each selected market, the enumerator was accompanied by a translator selected from the community and surveyed shop/stall/informal seller of foods. Prior to the interview, the objectives of the study were explained in local language to ensure that real current prices are collected and limit information bias. Supervisors and enumerator were specifically trained on the study methodology and administration of questionnaire. Including a field test.

The following data was collected through paper-based structured interviews:

1. Data on seasonality for each food, retail prices by month and season, weight in grams of unit in which foods are sold will be collected by interviewing all the shop keepers and local traders in each of the markets selected. The tool used for this data collection was the market survey tool.

2. Data on local dietary habits collected by interviewing 4 clients from the market, preferably women, to establish the acceptable frequency of consumption of the different foods. The tool used for this data collection was the dietary habits interview sheet.
After the interviews, the data was presented to a key informant (such as a community leader or a local NGO) to check the validity of the information.

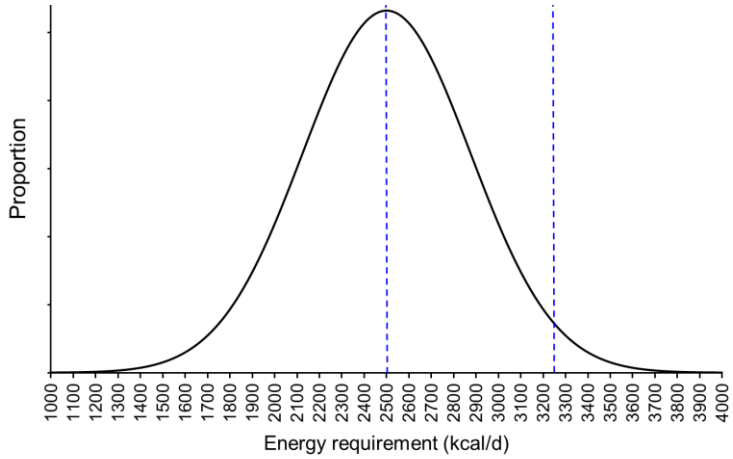
To ensure standardization of data collection, the teams undertook a training phase of 4 days on the methodology and interview questionnaires prior to the start of the data collection. The training was delivered by the researcher with the support of the supervisors. After the training, a field test of one day allowed to trouble shoot any deviation from the methodology. The data collection tools were reviewed after the field test when questions needed to be reformulated to improve clarity for the enumerators.

Supervision of enumerators was undertaken throughout the study to ensure the study progress was in line with the methodology. The supervisors ensured the quality of the data that was being collected by randomly reviewing completed questionnaires each day of the data collection. On-site trainings were provided when necessary.

ANNEX 4: Energy, Fats, Protein and micronutrient specifications

Energy specifications

Graph 11: distribution of average energy requirements in the population



The software applies the average energy requirements, as specified by the World Health Organization (WHO) and Food and Agriculture Organization (FAO) in Human energy requirements (2001). By definition, the average meets or exceeds the needs of fifty percent of the population, and does not meet the needs of fifty percent of the population. In order to mitigate this limitation, the software accepts a standard deviation from the mean. As no recommendation for standard deviation could be found in publications, a coefficient of variation of 15% has been applied to the mean to estimate the standard deviation from the average energy requirement (graph 9) as recommended in Save the Children CoD methodology.

Fat specifications

The needs of individuals for fat are specified as a minimum and maximum percentage of energy intake. The energy recommended from fat is then converted into grams of fat by applying an energy density of 9 kcal per gram of fat. The minimum and maximum percentage of energy intake varies by age group according to WHO/FAO, Fat and fatty acids in human nutrition (2008). For children aged 6-23 months graded downwards from 40 to 60 percent to 25 to 35 percent of energy. For children over 2 years and adults, it is recommended that 25 to 35 percent of energy comes from fat. For infants 0 to 6 months-old, specifications are based on fat content of breast milk, based on the assumption that the amount of fat in breast milk is sufficient to meet the needs of all infants under 6 months old.

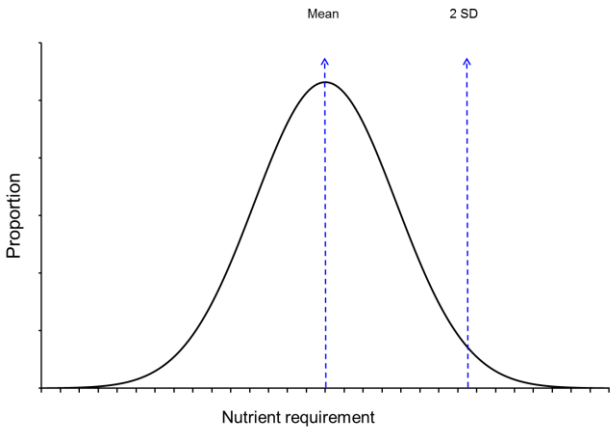
Protein specifications

The protein requirements are specified as the 95th percentile of the distribution of requirements per kilogram of body weight per day from WHO, Protein and amino acid requirements in human nutrition (2007). This means that the probability that any given individual's protein needs are met is 95 percent. The software applies weight of adults and children aged 0-18 years from WHO (2007) and (1983) growth references. For children of either sex, the mid-point in weight between male and female is applied. For children aged 1- 6 months, the recommended daily intake of protein is calculated from the quantity of protein contained in the amount of breast milk required to meet recommended average energy requirements. Similarly to fat specifications, it is assumed that the amount of protein in breast milk is sufficient to meet the needs of all infants under 6 months old.

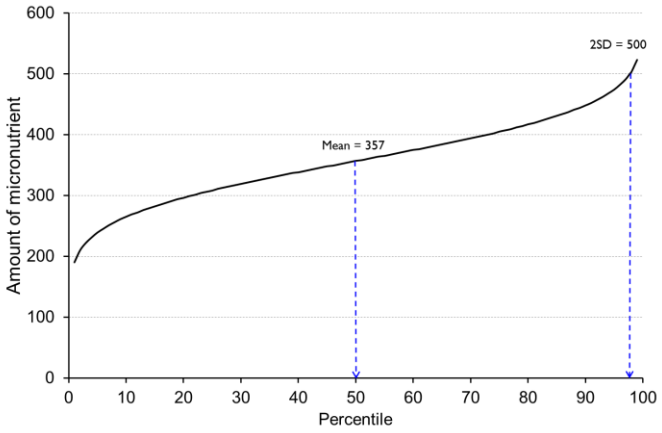
Micronutrient specifications

For each micronutrient, the requirement used by the software is the recommended nutrient intake (RNI). RNI is the daily intake, which "meets the nutrient requirements of almost all healthy individuals in an age and sex-specific population group". The RNIs are set at 2 standard deviation above the mean, as shown in graph 10. This means that RNI meet the nutrient requirements for 97.5 percent of the population, however the RNI value is too low to cover the highest nutrient needs of 2.5 percent of the population. The RNI values for the nine vitamins and four minerals are extracted from the WHO/FAO, Vitamin and mineral requirements in human nutrition (2004).

It is important to note that RNIs do not represent the value needed for every individual to meet their nutrient needs but a value set to minimise the risk of nutrient deficiency. This feature is very powerful when it comes to cost optimisation. Graph 10 shows the effect of the normal distribution on the amount of a hypothetical micronutrient. After 2 standard deviation above the mean, the value of micronutrient needs rises exponentially. This has a great impact on the cost of meeting nutrient specifications after 2 standard deviation above the mean for the highest 2.5% of the population as can be shown in graph 11.



Graph 12: normal distribution of nutrient needs in the population

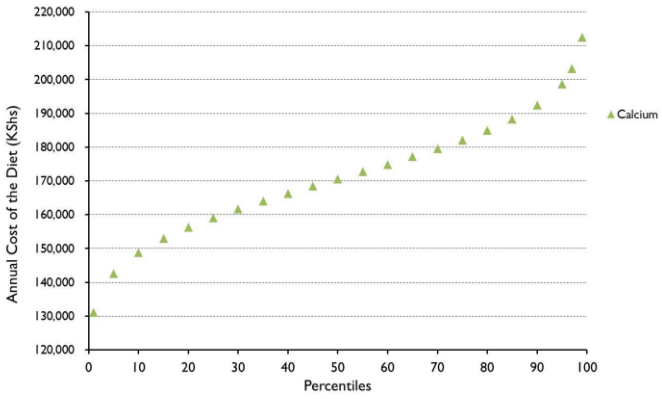


Graph 13: value of micronutrient need according to normal distribution, Source: Save the Children UK

For instance, calcium is a micronutrient for which requirements are high and that is found in important quantities in food sources that are expensive. Meeting calcium requirements often drives the cost of SNUT diets. For the last 2.5 percent of the population, the exponential increase in calcium requirements greatly impacts the cost to meeting calcium requirements. In Kenya, the annual cost of the diet was sharply risen from 200,000 to above 215,000 Kenyan Shillings or about 7% increase in cost for this nutrient only (graph 12)(24).

In addition, for vitamin A, vitamin C, niacin, calcium, and iron, where evidence suggests that nutrients could be toxic or have harmful effects, upper tolerable nutrient intake levels (ULs) have also been specified, set by WHO. UL is an upper safe limit defined as "the maximum intake from food that is unlikely to pose risk of adverse health effects from excess in almost all healthy individuals in an age and sex-specific population group". The software will not allow these limits to be exceeded and if they are met for one nutrient the specifications for other nutrients may not be reached, despite the availability of foods that could provide these missing nutrients.

Ultimately, this section highlights that the estimation of the cost of a SNUT diet is a complex calculations relying on a set of parameters. When possible, parameters were based on available literature, such as the parameters related to nutrient specifications. When literature was not available, parameters had to be defined arbitrarily. An understanding of these parameters is important to interpret output and to keep in mind that most parameters were set with the objective to minimize risks for nutrient deficiency.



Graph 14: Effect of the normal distribution of the RNI on the cost of meeting specifications, Source: Save the Children UK

Annex 5: Detailed SNUT Diet

Assessment: zone 8 - Fianarantsoa
Season: Aout 2015
Model: SNUT
Diet: SNUT (Staple-adjusted NUT)

The cost of the foods and the daily quantities in grams (g) selected by the software

	10-Katsaka, Tsako, (Mais jaune, concasse, cru) (Maize, cracked,	12-Vary fotsy, Tsipala (Riz blanc local long) (Rice, white, long grain,	29- Voanemba, Ibjy (Haricot blanc point noir) (Cowpea, dried,	39-Soza voany, (Soja seche en grain) (Soybean, dried, raw)	60-Habokabon-kena kisoa, Rabon-kena Koso, (Poumons de porc)	64- Trondro Maina, Fia maike, Fiao maina,	75-Pirina maina, (Petits poissons seches) (Fish, small, dried, fresh	103-Voatavo, Taboara, (Citrouille) (Pumpkin, raw)	124-Menak palme (huile de palme) (Oil, palm)	Breast milk	**Total Food Weight**
1 x Man, 30-59y, 65 kg, moderately active	70	233		230		291	4	898			1 726
1 x Woman, 30-59y, 50 kg, moderately active (1 x Lactation, 7-12 months)	121	180	10	180	1	225	35	899	4		1 656
1 x Female 14-15 years		184	24	70	13	230	116	553	27		1 216
1 x Child (either sex) 6-7 years		113		106		141	31	273	8		673
1 x Child (either sex) 9-11 months				2	8	68	29	185		583	875
Total edible weight	**191**	**710**	**34**	**589**	**22**	**955**	**216**	**2 807**	**39**	**583**	**6 145**
Total weight	**191**	**710**	**34**	**589**	**22**	**955**	**216**	**3 554**	**39**	**583**	**6 891**

The daily number of servings of the foods selected by the software

1 x Man, 30-59y, 65 kg, moderately active	1	1		3		3	1	3		
1 x Woman, 30-59y, 50 kg, moderately active (1 x Lactation, 7-12 months)	1	1	1	3	1	3	1	3	1	
1 x Female 14-15 years		1	1	2	1	3	2	2	1	

1 x Child (either sex) 6-7 years		1		3		3	1	2	1	
1 x Child (either sex) 9-11 months				1	1	3	2	3		1
Total	**2**	**4**	**2**	**12**	**3**	**15**	**7**	**13**	**3**	**1**

Cost of the Diet (MGA):

1 x Man, 30-59y, 65 kg, moderately active	48.11	266.84		510.64		1280.87	57.55	129.79			**2293.79**
1 x Woman, 30-59y, 50 kg, moderately active (1 x Lactation, 7-12 months)	83.46	206.66	17.64	399.85	5.54	991.68	457.86	129.94	18.77		**2311.40**
1 x Female 14-15 years		210.79	39.66	154.25	63.81	1011.49	1518.93	79.96	139.74		**3218.63**
1 x Child (either sex) 6-7 years		129.18		235.71		620.63	412.30	39.43	42.58		**1479.83**
1 x Child (either sex) 9-11 months				4.68	38.58	298.43	385.69	26.70		0.00	**754.08**
Total Cost of the Diet	**131.56**	**813.46**	**57.30**	**1305.14**	**107.94**	**4203.09**	**2832.34**	**405.81**	**201.09**	**0.00**	**10057.72**

The daily quantity of each nutrient provided by the edible portion of foods selected by the software

Food Name	Energy (kcal)	Protein (g)	Fat (g)	Vitamin A (µg RE)	Vitamin C (mg)	Vitamin B1 (mg)	Vitamin B2 (mg)	Niacin (mg NE)	Pantothenic acid (mg)	Vitamin B6 (mg)	Folic acid (µg DFE)	Vitamin B12 (µg)	Calcium (mg)	Iron (mg)	Magnesium (mg)	Zinc (mg)
Grains and grain-based products																
10-Katsaka, Tsako, (Mais jaune, concasse,	691.5	15.5	6.9	0.0	0.0	0.7	0.4	8.7	0.8	0.6	47.8	0.0	2.8	0.3	242.6	3.4
12-Vary fotsy, Tsipala (Riz blanc local long)	2 590.4	50.6	4.7	0.0	0.0	0.5	0.3	11.4	7.2	1.2	56.8	0.0	47.7	0.3	177.4	7.7
Legumes, nuts and seeds																
29- Voanemba, lojy (Haricot blanc point noir)	104.2	6.9	0.4	0.9	0.0	0.2	0.1	1.9	0.4	0.1	186.9	0.0	5.1	0.1	47.7	1.2
39-Soza voany, (Soja seche en grain)	2 495.3	193.8	117.3	6.4	0.0	4.3	2.9	46.5	3.0	2.5	588.5	0.0	339.8	3.3	1 218.2	33.5
Meat and offal																
60-Habokabon-kena kisoa, Rabon-kena Koso,	18.3	3.0	0.6	0.0	2.7	0.0	0.1	0.7	0.2	0.0	0.6	0.6	0.5	1.0	3.0	0.4
Fish, seafood, amphibians and invertebrates																
64- Trondro Maina, Fia maike, Filao maina,	2 772.3	540.1	51.9	52.7	2.3	1.1	1.7	168.7	7.9	5.7	270.4	59.8	1 979.5	4.3	1 103.1	27.9
75-Pirina maina, (Petits poissons seches)	723.1	126.5	20.3	0.0	0.0	0.2	0.6	41.3	3.3	0.9	60.4	25.9	1 174.2	1.3	302.2	11.2
Vegetables and vegetable products																
103-Voatavo, Taboara, (Citrouille) (Pumpkin,	505.3	39.3	8.4	10 363.6	591.1	2.0	1.7	22.5	8.1	1.7	449.2	0.0	698.3	1.0	280.7	3.0

Oils and fats																
124-Menak palme (huile de palme) (Oil, palm)	353.2	0.0	39.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Breast Milk																
Breast milk	378.9	6.1	22.7	291.5	23.3	0.1	0.2	2.5	1.0	0.1	49.6	0.6	52.2	0.0	20.4	0.7
Total	**10**	**981.9**	**272.5**	**10 715.0**	**619.3**	**9.1**	**8.0**	**304.1**	**31.9**	**12.6**	**1 710.2**	**86.9**	**4 300.0**	**11.7**	**3 395.3**	**89.2**
Target amount for the household	10 632.5	187.4	270.3	2 900.0	215.0	4.7	4.9	61.0	21.8	5.4	1 580.0	9.5	4 300.0	9.0	880.0	30.3

The percentage (%) of each nutrient target provided by the edible portion of foods selected by the software

Food Name	Energy	Protein	Fat	Vitamin A	Vitamin C	Vitamin B1	Vitamin B2	Niacin	Pantothenic acid	Vitamin B6	Folic acid	Vitamin B12	Calcium	Iron	Magnesium	Zinc
Grains and grain-based products																
10-Katsaka, Tsako, (Mais jaune, concasse,	6.5	8.3	2.5	0.0	0.0	15.9	7.8	14.2	3.8	10.6	3.0	0.0	0.1	3.7	27.6	11.3
12-Vary fotsy, Tsipala (Riz blanc local long)	24.4	27.0	1.7	0.0	0.0	10.6	7.1	18.6	33.0	21.6	3.6	0.0	1.1	3.2	20.2	25.5
Legumes, nuts and seeds																
29- Voanemba, lojy (Haricot blanc point noir)	1.0	3.7	0.2	0.0	0.0	3.8	1.1	3.1	1.7	1.6	11.8	0.0	0.1	1.3	5.4	3.8
39-Soza voany, (Soja seche en grain)	23.5	103.4	43.4	0.2	0.0	91.4	60.1	76.2	13.6	45.4	37.2	0.0	7.9	37.2	138.4	110.7
Meat and offal																
60-Habokabon-kena kisoa, Rabon-kena Koso,	0.2	1.6	0.2	0.0	1.2	0.4	1.9	1.2	0.9	0.4	0.0	6.2	0.0	11.4	0.3	1.4
Fish, seafood, amphibians and invertebrates																
64- Trondro Maina, Fia maike, Filao maina,	26.1	288.2	19.2	1.8	1.1	23.0	34.5	276.5	36.4	105.2	17.1	630.0	46.0	47.9	125.4	92.1
75-Pirina maina, (Petits poissons seches)	6.8	67.5	7.5	0.0	0.0	4.6	11.9	67.7	15.2	16.4	3.8	272.6	27.3	15.0	34.3	37.0
Vegetables and vegetable products																
103-Voatavo, Taboara, (Citrouille) (Pumpkin,	4.8	21.0	3.1	357.4	274.9	41.8	34.4	36.8	37.2	31.7	28.4	0.0	16.2	11.0	31.9	9.9
Oils and fats																
124-Menak palme (huile de palme) (Oil, palm)	3.3	0.0	14.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Breast Milk																
Breast milk	3.6	3.3	8.4	10.1	10.8	2.6	4.2	4.1	4.8	1.0	3.1	6.0	1.2	0.0	2.3	2.3
Total	**100.0**	**524.0**	**100.8**	**369.5**	**288.1**	**194.1**	**162.8**	**498.5**	**146.5**	**233.9**	**108.2**	**914.8**	**100.0**	**130.6**	**385.8**	**294.2**

The percentage (%) of each nutrient target provided by the foods selected by the software

Annex 6: geographical localization of the markets selected in the survey