Technical series on

Adapting to Climate Sensitive Health Impacts

Undernutrition

World Health Organization

Adapting to climate sensitive health impacts: undernutrition

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Series introduction

A vulnerability and adaptation (V&A) assessment is a vital first step in adapting to climate change. This technical guide on V&A assessment for undernutrition and climate change is part of a series of World Health Organization (WHO) guidance aiming to inform the management of priority climate-sensitive health impacts to climate change. Specifically, this document is intended for use in conjunction with the general WHO guidance on conducting health vulnerability and adaptation assessments "*Protecting health from climate change: vulnerability and adaptation assessment*" (available from: http://www.who.int/entity/globalchange/publications/Final_Climate_Change.pdf, accessed 12 November 2018).

This technical series was created with a two-fold purpose: (i) to help clarify the relationships and casual links that exist between climate change and priority health outcomes; and (ii) to offer specific direction and resources for assessing these associations and designing adaptation options for protecting health in a changing climate.

Each guide follows the same structure of the V&A assessment process and provides specific resources and information on the priority theme as follows:

Section1. **Conducting a thematic study within a V&A assessment** describes how to use this guide in conjunction with the main V&A assessment guidance, and includes additional considerations for setting up a thematic assessment.

Section2. **Overview** comprises a general introduction on the targeted topic, including definitions, the scope and scale of its global burden and causal mechanisms.

Section3. **Climate change and the priority health issue** explains how a specific health outcome is influenced by climate variability and climate change.

Section4. **Identifying vulnerable populations** provides suggestions on how to determine populations and regions that are vulnerable to the health impacts of climate variability and change.

Section5. **Establishing baselines** suggests relevant dimensions and metrics that can be used to understand current health and risk conditions, and form the basis of a study that can also be monitored over time.

Section6. **Assessing sensitivity** provides guidance on different options and variables that can be used to understand and measure the degree to which climate variability and change influences the distribution and occurrence of the health outcome of interest.

Section7. **Anticipating future risks and impacts** explains ways to understand how changing climatic conditions may influence future health status for priority populations and regions.

Section8. **Identifying adaptation options** provides suggestions and resources on how to identify weaknesses in current and planned interventions, and prioritize relevant responses to prevent and adequately manage climate-related health risks.

Section9. **Monitoring adaptation progress** presents considerations for informing decisions and monitoring relevant changes in population health status, exposure to climate hazards, relevant risk factors, as well as the effectiveness of protective measures in place.

Section10. **Conclusions**

References, terminology and available resources and tools are provided throughout or as annexes.

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Abbreviations

AIDS	acquired immune deficiency syndrome
BMI	body mass index
CO_2	carbon dioxide
DALY	disability adjusted life years
DHS	demographic and health surveys
ENSO	El Niño–Southern Oscillation
FAO	Food and Agriculture Organization
FEWS	Famine Early Warning System
GINA	Global database on the Implementation of Nutrition Action
HIV	human immunodeficiency virus
ICN_2	Second International Conference on Nutrition
IMPACT	International Model for Policy Analysis of Agricultural Commodities and Trade
IPC	Integrated Food Security Phase Classification
IPCC	Intergovernmental Panel on Climate Change
IYCF	infant and young child feeding
JMP	WHO/UNICEF Joint Monitoring Programme for Water Supply, Sanitation and Hygiene
LMIC	low- and middle-income countries
MICS	multiple indicator cluster surveys
NAPs	national adaptation plans
NLIS	Nutrition Landscape Information System
RUTF	ready-to-use therapeutic food
UN	United Nations
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNICEF	UN International Children's Emergency Fund
UNSCN	UN System Standing Committee on Nutrition
V&A	vulnerability and adaptation
WASH	water, sanitation and hygiene
WB	World Bank
WCRP	World Climate Research Programme
WGRC	WCRP Working Group on Regional Climate
WHO	World Health Organization

Section 1

Conducting a thematic vulnerability and adaptation (V&A) study on undernutrition

This guide presents a basis for understanding how nutrition, specifically undernutrition, is currently influenced by climate and weather, and may be further exacerbated by climate change. It provides guidance on how to: (i) identify populations and regions vulnerable to undernutrition and the reasons for their vulnerability; (ii) establish relevant baselines that can be analysed and monitored; (iii) conduct analyses to project how undernutrition may be impacted in the future due to climate change; and (iv) identify appropriate responses to mitigate and monitor these risks over time. This guide provides information specific to the analysis of undernutrition and climate change, and should be used in conjunction with the main WHO V&A guidance.

You are likely using this guide because undernutrition was identified as a thematic priority during the scoping and framing steps of a national V&A assessment or other climate impact assessments. Additional thematic teams or consultants may be conducting similar assessments on other priority issues as part of an overall V&A process. Appropriate coordination, particularly with assessment teams of diarrhoeal disease and food and nutrition security is advised, as similar data and analyses may be used for multiple analyses within this study.

Although the ultimate effects of malnutrition are on individual health, the underlying causes reflect household behaviours and result from conditions in other sectors particularly agriculture and water. The complex nature of undernutrition means that a multisectoral approach is essential to assess, predict, monitor and protect the nutritional status of a population. Climate and nutrition assessments thus require the input, data and experience of stakeholders, decision-makers and experts from various fields. The relevant stakeholders to consider involving in the assessment process, as data providers, analysts or reviewers include:

- Government nutrition programmes and nutrition working groups
- Local and international nongovernmental organizations and United Nations (UN) agencies with national nutrition and food security data and experience
- Medical and health personnel
- Agriculture, livestock and fisheries experts
- Water and sanitation experts
- Climate and national meteorological experts
- Local universities and research institutes
- International experts with nutrition experience in your country.

There are no set rules or formats for V&A assessments. Each study will be unique to the national situation, the mandate of the study, as well as the data and analytical resources available. This study should serve to bridge existing, but currently separate analyses of nutrition, food security and climate impacts.

Secondary data use is encouraged and a thorough scoping of available resources, data and partners is recommended. Qualitative and quantitative data should be used in combination to create a complete understanding of vulnerability and future impacts of climate. Data gaps are to be expected and limitations should be noted as areas of action for future research.

It is important to keep in mind that a V&A assessment is not a one-time study, but a continuous process that serves as the backbone for climate adaptation decision-making.

Section 2

Overview of malnutrition and scope

Malnutrition refers to all deviations from optimal nutritional status, and includes a spectrum of disorders from starvation to obesity *(1)*. Although obesity is an increasing global concern with relevant climate associations (see Box 1 on page 6), this guide focuses on the nutrient-deficiency aspect of malnutrition, in either macronutrients (referred to as undernutrition) or micronutrients (such as iron, zinc, iodine, vitamin A).

Undernutrition comprises both acute and chronic forms and is used to quantify future health burdens. Acute undernutrition is an important measurement of acute food and nutritional insecurity, often indicating crisis-level conditions for the individual or community. Acute undernutrition is reflected by low weight-for-height (wasting). Chronic undernutrition reflects persistent nutritional insecurity; often due to the presence of disease, food insecurity in the absence of hazards/shocks, or high frequency of years with acute food insecurity *(2)*. Chronic undernutrition in children, presenting as low-height-for-age (stunting), results in irreversible impairments in physical and mental development. Deficiencies of micronutrients, vitamins and/or minerals, are often referred to as "hidden hunger" as they are not necessarily accompanied by wasting or stunting, but can have serious consequences for health and development. It is important to consider the diverse forms of malnutrition as the risk factors, associations with climate and appropriate solutions, may differ and occur at varied timescales. These are described in more detail in the Glossary at the end of this document (Annex 2).

Undernutrition does not result from lack of food availability alone. The causes of undernutrition, and other forms of malnutrition, operate dynamically at different levels from distal to proximal. As shown in Figure 1 (in Section 3), the immediate causes of maternal and child undernutrition result from inadequate dietary intake and disease, which are determined principally by *(3,4)*:

- poor household access to sufficient, nutritious and safe food;
- inadequate maternal and child care, and feeding practices; and
- poor household access to and use of quality health services, and a healthy and hygienic environment, including water and sanitation.

These underlying determinants are themselves influenced by basic conditions of local, national and regional development within a natural, social, economic, political, institutional and security context *(5)*. The right hand arrows in Figure 1 show how the consequences of undernutrition result in a feedback loop to the immediate, underlying and basic causes, perpetuating the cycle of undernutrition, poverty and inequities for individuals and households.

Malnutrition is a systemic and intergenerational problem and one of the most important determinants of health. Although malnutrition can occur at any point in the lifecycle, fetuses, infants and young children are most vulnerable to the effects of malnutrition because of higher nutrient requirements during growth and development. During the critical first 1000 days of a child's life – period from conception until the second birthday – a lack of adequate and appropriate nutrients can lead to irreversible impaired mental and physical development with severe consequences in later life *(6)*;

affecting adult size, intellectual ability, economic productivity, reproductive performance, and immunological, metabolic and cardiovascular health *(7)*. Individuals who experience undernutrition are often not able to make a full contribution to the social and economic development of their households, communities and nations when they become adults, and often pass these limitations on to their children.

Diarrhoea is the leading cause of malnutrition among children under five years of age *(8)*. Diarrhoeal disease and malnutrition form a vicious cycle. On the one hand, malnutrition is an underlying risk factor for diarrhoeal disease transmission and increases the burden of disease. For example, the mortality risk from diarrhoeal diseases is increased more than nine-fold in severely undernourished children *(4)*. On the other hand, diarrhoeal episodes are accompanied with a loss of appetite, malabsorption of nutrients and increased metabolism, which in combination often leads to malnutrition. In addition, undernutrition increases the duration, severity and risk of death from other diseases, such as acute respiratory infections, measles, and malaria, and drives further cyclical challenges by decreasing the efficacy of management of HIV/AIDS *(9)* and other major diseases.

Malnutrition is one of the world's most serious public health challenges with deep and systemic consequences for individuals, households, the society and economies at large. Although the global burden of undernutrition has decreased markedly since 1990, undernutrition remains a significant health and development issue. In 2016, among children under the age of five years globally, 154.8 million were stunted (22.9%), and 51.7 million suffered from wasting (7.7%) with nearly a third of these being severely wasted *(5,10)*. Worldwide, two billion people suffer from one or more micronutrient deficiencies *(11)*. Moreover, several forms of malnutrition, such as stunting, wasting, overweight and obesity may exist together in the same country, household or person *(11)*. It is estimated that undernutrition is responsible for 45% of deaths of children younger than five years of age which equates to more than three million preventable deaths each year *(5)*.

Although the scale of the problem is significant, in 2013 it was estimated that 80% of the world's child stunting occurred in only 14 countries *(12)*.[a,b] Table 1 breaks down recent WHO malnutrition statistics among children under five years of age, by region.

a Bangladesh, China, Democratic Republic of Congo, Egypt, Ethiopia, India, Indonesia, Kenya, Nigeria, Pakistan, Philippines, Sudan, Uganda, United Republic of Tanzania.

b See https://data.unicef.org/topic/nutrition/malnutrition for a map showing the global distribution of undernutrition mortality of children under five years of age. South Asia and Africa experience the most significant undernutrition mortality rates.

Table 1: Global distribution of malnutrition among children under five years of age in 2016, by region

Region	% of children under five years			
	Wasted	Severely wasted	Stunted	Overweight
South-East Asia	15.3	5.0	33.8	5.3
Africa	7.4	2.2	33.5	4.1
East Mediterranean	9.1	3.8	25.1	6.7
Western Pacific	2.4	0.6	7.0	5.2
Americas	0.9	0.1	6.6	7.1
Global	**7.7**	**2.5**	**22.9**	**6.0**

Source: Joint child malnutrition estimates 2017 (UNICEF-WHO-WB). WHO website (http://apps.who.int/gho/data/node.wrapper.nutrition-2016, accessed 18 November 2018).

Combatting malnutrition, in all its forms, has increasingly been identified as a global development priority. One of the Sustainable Development Goals (SDGs), Goal 2: Zero hunger, directly addresses global malnutrition *(13)*. Many of the other SDGs, particularly Goal 3: Good health and well-being and Goal 6: Clean water and sanitation, have a symbiotic relationship with Goal 2. Addressing climate change also features strongly in SDGs Goal 13: Climate action and Goal 7: Affordable and clean energy.

The Second International Conference on Nutrition (ICN2), held in November 2014, was a high-level intergovernmental conference that focused global attention on malnutrition in all its forms – undernutrition, micronutrient deficiencies, overweight and obesity. It was the first world forum to address global nutrition issues and challenges in the 21st century *(14)*. The Rome Declaration on Nutrition and accompanying Framework for Action for its implementation were adopted at ICN2. Following ICN2, in April 2016 the UN General Assembly agreed to a resolution proclaiming the UN Decade of Action on Nutrition (2016–2025) endorsing the Rome Declaration *(15)*. The Framework for Action commits governments to exercise their primary role and responsibility for addressing undernourishment, stunting, wasting, underweight and overweight in children under five years of age, and anaemia in women and children, among other micronutrient deficiencies. It also commits them to reverse the rising trends in overweight and obesity and reduce the burden of diet-related noncommunicable diseases in all age groups. The new resolution invites international partners, civil society, private sector and academia to actively support governments to ensure full implementation of the steps outlined in the Rome Declaration and Framework for Action.

Box 1: Malnutrition in all its forms

This guidance focuses on undernutrition, including stunting, wasting and micronutrient deficiencies. However, in your country context it may also be important to consider all forms of malnutrition including overweight and obesity. Like undernutrition, overweight and obesity can coexist with micronutrient deficiencies. Furthermore, dietary patterns that result in overweight and obesity can also lead to serious diet-related noncommunicable diseases later in life such as type-2 diabetes, cardiovascular disease and some cancers *(16)*.

In 2016, more than an estimated 1.9 billion adults, 41 million children under five years of age and over 340 million children and adolescents aged five to 19 years were overweight or obese. Overweight and obesity are linked to more deaths worldwide than underweight; and worldwide there are more people who are obese than underweight *(17)*. This is not limited to high-income countries; for example, in Africa, the number of overweight children under five years of age has increased by nearly 50% since 2000 and almost half of the children under five years of age who were overweight or obese in 2016 lived in Asia *(17)*.

Furthermore, many developing countries are experiencing the double burden of malnutrition with high burdens of both undernutrition and overweight and obesity along with high diet-related noncommunicable disease burdens *(18)*.

There is emerging evidence that climate change will adversely affect the risk of overweight and obesity and diet-related noncommunicable diseases. Availability of local foods is likely to decrease in some areas due to the negative effect of climate change on agriculture and fisheries, a particular concern for populations living a predominantly subsistence lifestyle. Additionally, the expected reduction in global crop yields due to climate change may increase food prices further exacerbating food access, particularly for lower income populations *(19)*.

Furthermore, climate change-induced migration, much of which is likely to be rural–urban migration, is predicted to become a phenomenon increasingly driven by, and resulting in, increased food insecurity *(20,21)*. Urbanization has been associated with increased risk of overweight and obesity and diet-related noncommunicable diseases *(22)*. Food assistance provided during an emergency response can weaken long-term food and nutrition security *(23)*, including a persistence of low-quality, imported foods in the local diet long after the humanitarian response has concluded *(24,25)*.

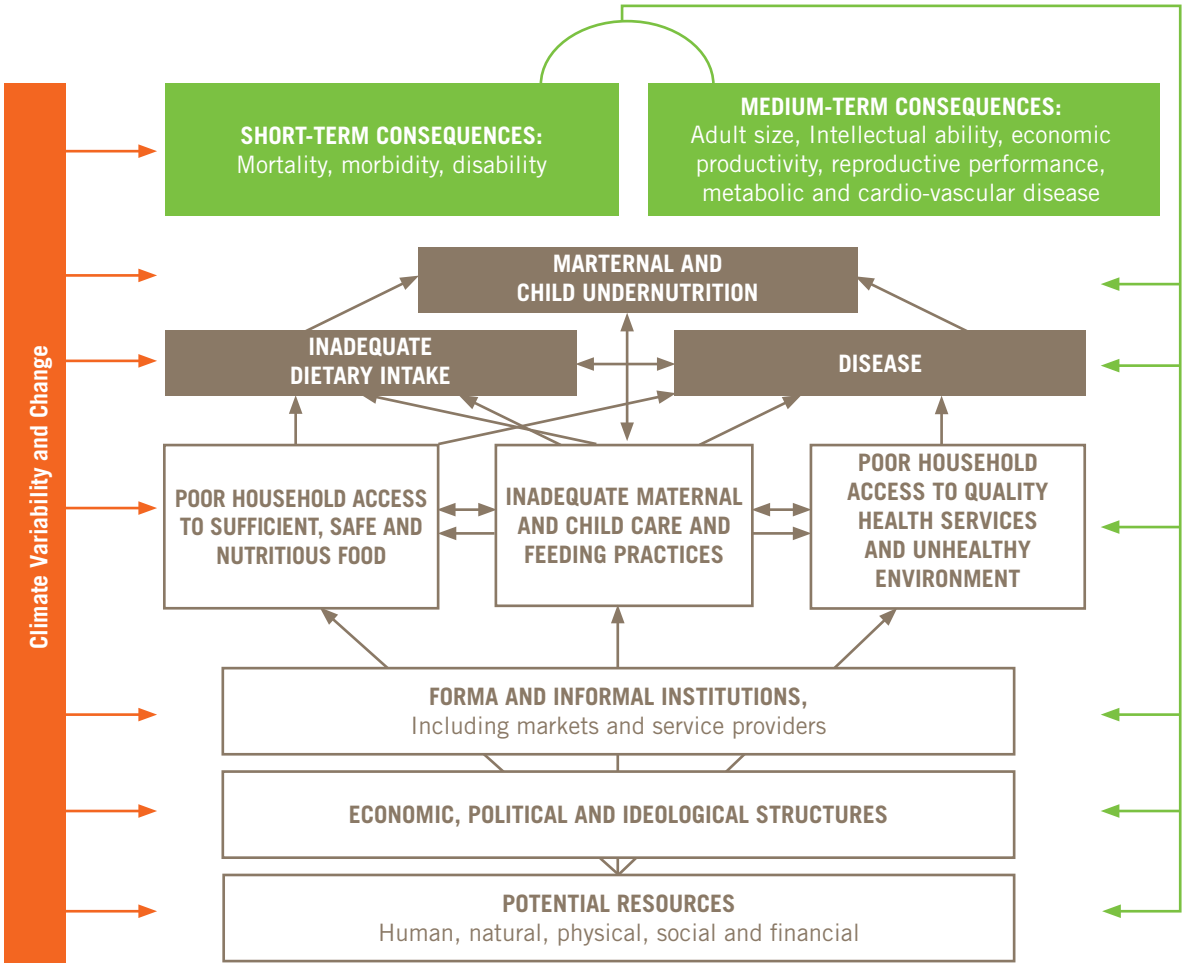
It is likely that these, and other, pathways leading to climate change-induced food and nutrition insecurity will exacerbate already-changing dietary patterns comprising increased consumption of high energy and low nutrient dense imported and processed foods. The links between climate change and overweight and obesity is a new field and further research is needed. However, if overweight and obesity and diet-related noncommunicable diseases already present significant health burdens for your country it may be pertinent to consider them in the V&A assessment.

Section 3

Climate change and undernutrition

An increasingly large body of evidence indicates that undernutrition in all populations, particularly vulnerable populations (such as women, infants, children and adolescents), is likely to be magnified by climate change, without effective countermeasures. The impacts of climate variability and change on nutrition occur indirectly, by exacerbating existing threats to "food, care and health". The mechanisms through which climate change jeopardizes "food, care and health"-related determinants of nutrition, are myriad. The arrows on the left in Figure 1 highlight that climate variability and change can also affect the entire food system at multiple levels (immediate, underlying and basic) *(26)*.

Figure 1: Conceptual framework: climate and nutrition security



Source: adapted from UNICEF, 1990 *(3)*

The ramifications of climate change on nutritional outcomes in the future are estimated to be significant, and the exacerbation of current threats to food and nutritional security will only make it harder and more expensive to reduce undernutrition in the coming decades *(27)*. Furthermore, undernutrition undermines the health and coping mechanisms of vulnerable populations, and lessens their capacities to be resilient and adapt to other consequences of climate change. The Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) concludes with *high confidence* "that climate change will have a substantial negative impact on (i) per capita calorie availability; (ii) childhood undernutrition, particularly stunting; and (iii) undernutrition-related child deaths and DALYs (disability adjusted life years) lost in developing countries" *(28)*.

Existing research predicts that some of the effects of climate change on undernutrition can in part be alleviated by economic development *(29,30)*. However, in sub-Saharan Africa – the only region where the number of stunted children has risen despite economic development – it is projected that climate change will lead to a net increase in children suffering from undernutrition *(19,31,32)*. More specifically, it is projected that there will be an additional 6.2 million children moderately stunted and 3.9 million severely stunted by 2050 compared to a future without climate change *(32)*. Conducting a V&A assessment can help refine such estimates by building understanding and evidence on the degree to which these projections may manifest at national and subnational levels.

The following sections state the identified likely causal pathways through which climate change is expected to alter the conditions of "food, care and health". It is advised that research studies primarily explore how climate change may alter these three immediate and underlying causes, as linkages between basic causes and nutrition outcomes, while important, are difficult to measure.

Food: Household access to sufficient, nutritious and safe food

Climate change is expected to affect all aspects of food security (availability, access, utilization and stability) *(26,33,34)*.

Availability

Food availability will be directly impacted by increased climate variability and long term climate change *(35,36)*. Longer term warming, increased atmospheric carbon dioxide (CO_2), and altered precipitation patterns will have wide sweeping impacts on agricultural production and livelihoods assets *(33,37)* and increase irrigation water requirements *(11)*. In general, crop productivity is expected to increase in higher latitudes (i.e. Northern Europe and Northern America) and decrease across regions that are already highly affected by malnutrition (i.e. Africa, South and South-East Asia, South America and the Pacific) *(34,38)*. For example, it is projected that climate change leads to reduced crop productivity of 8% in Africa and South Asia *(39)*. Increasing ambient and sea-surface temperature rise, sea-level rise and salinization of land, along with species shifts is projected to negatively impact land and marine environmental conditions essential for food production and harvesting *(35)*. Warmer temperatures will expose crops, livestock, fish and humans to new pests and disease vectors *(35)*. Regional variations, increasing soil and water salinization, soil erosion, ocean acidification, glacial loss, changes in pests and plant diseases, and food price variability, particularly in areas dependent on rain-fed agriculture and marine food sources, may all take their toll and ultimately influence household and individual food consumption. Rain-fed regions may be particularly jeopardized as 80% of cultivated land and 100%

of pastureland is weather dependent, with likely reduced yields, quality and diversity in both wild and cultivated food products. However, it is estimated that the increased frequency of climate extremes may have greater negative impacts on crop yields than mean climate change *(37)*.

Experts predict that climate change will result in unprecedented extremes of both slow onset climate events (i.e. intensified and consecutive droughts across some areas) and extreme events (i.e. the increased length, frequency and/or intensity of heat waves; increased frequency of heavy precipitation and flooding in many regions; upward trends in extreme coastal storms and high water levels; increased frequency and/or intensity of tropical cyclones/hurricanes and changes in flood patterns) *(33,40)*. Regional trends in disaster-related food production and food storage losses and damages may become notable.

A further aspect of food availability, food safety and quality, which can be compromised by warmer ambient temperatures, is that it encourages microbial growth, and increases spoilage and transmission of food-borne illnesses. Variability in precipitation and temperatures and increased humidity can stress crops and stored grains, and shift the range of aflatoxin-producing fungi, leading to pre- and postharvest spoilage of crops *(41–43)*. Increased sea surface temperatures increase the formation of poisonous toxins as well as *Vibrios*, that are absorbed in fish and shellfish, increasing the risk of ciguatera and other marine products poisoning *(44,45)*. Increased atmospheric CO_2 may increase plant mass, but displace nitrogen necessary for protein synthesis in important crops such as wheat, soybeans and rice *(46–49)*; as well as reduce mineral content and increase toxic cyanide in cassava leaves (an important staple food for many) *(33,50,51)*. Thus, higher CO_2 levels may lead to masked micronutrient deficiencies while increasing the overall caloric intake of affected populations. However, this impact highly depends on economic and behavioural changes *(33)*.

Access

A key determinant for access is the price of food which strongly reacts to fluctuations in global production following extreme climate-related events and longer-term reduced crop yields resulting from climate change *(33)*. As a result of such events, the share of household income spent to purchase food, particularly for subsistence farmers, significantly increases, with consequences for household diets. The degree to which the food security of poor populations is affected by rising food prices depends on the percentage of food from their own food production, the response of the agricultural labour market and dependence on international trade *(52,53)*. In general, urban consumers, which constitute a growing population in many developing countries, are most affected due to their limited ability to engage in subsistence farming and strong dependency on staple foods *(33,52)*. Resource-poor households commonly prioritize calorie-rich but nutrient-poor foods as an adaptation strategy to reduced food availability and increased food prices *(54)*. In the long term, the recurrent and intense nature of such events can increasingly destabilize regional and local food systems *(11,35)*, with a potential to trigger food crises, acute malnutrition, and even famines.

Utilization

Food use and consumption patterns are likely to change as diverse cultivated or local wild food varieties become available or unavailable, and new varieties are introduced as adaptations which the population may or may not be familiar with or find palatable. This may result in reduced diet quality due to increased consumption of low-quality imported foods, particularly high-energy low-nutrient

foods. Reduced nutrient uptake is observed during diarrhoeal episodes, which are caused by climate-sensitive pathways, such as reduced water quality, increased risk of foodborne diseases or increased risk of transmission during person-to-person contact, all of which are exacerbated by the lack of adequate water, sanitation and hygiene *(34)*. Furthermore, the likely adverse effects of climate change on the mineral content of some crops may reduce diet quality *(33)*.

Stability

There is increasing evidence that climate change, and specifically extreme weather events, have a negative impact on the stability of the food system *(33)*. Food prices are extremely sensitive to shocks on both supply and demand sides *(34)*. Fluctuations negatively affect: household food availability, access and diet quality; access to social and health services; and the quality of infant and young child care *(55,56)*. The stability of economic returns to farmers and the access to purchased food for poor populations is also jeopardized by the price volatility of global food markets, which may result from extreme weather events *(33)*. These events can also have long-lasting impacts on the nutritional status of the affected population if infrastructure crucial for providing access to sufficient, nutritious and safe food is damaged or destroyed and recovery capacity is low. Droughts and floods are a particular threat to food stability and could bring about both chronic and transitory food and nutrition insecurity *(36)*. Increasing instability of food supplies, due to shocks and pressures of climate change, will most likely lead to increase in the frequency and magnitude of food emergencies which may ultimately lead to sociopolitical instability, conflict and migration *(57)*. Maintaining a stable food supply and access to food for growing and migrating populations will be increasingly influenced by an unstable climate, particularly for precarious local food systems in rain-fed areas.

Food and nutrition security, biodiversity and climate change

Human nutrition is both directly and indirectly dependent upon biodiversity and impacts upon it. Biodiversity provides us with dietary diversity, which means a wide range of foods and nutrients that is crucial for human nutrition.[c] Additionally, biodiversity "underpins critical supporting ecosystem services, such as pollination and soil fertility, essential to food production, both in terms of quantity and quality".[d] Climate change is expected to adversely affect biodiversity impacting on agriculture, food safety and food security, which in turn will reduce nutrition security.

c Connecting global priorities, biodiversity and human health, summary of the state of knowledge review. Geneva: World Health Organization and Secretariat of the Convention on Biological Diversity; 2015 (https://www.cbd.int/health/SOK-biodiversity-en.pdf, accessed 29 November 2018).

d ibid p97.

Table 2: Impacts of climate change on food security, and resulting consequences for human health and nutrition

Climate impact and mechanism affected	Summarized consequences for health and nutrition
Increases in mean global temperatures and temperature extremes • Crop and livestock losses due to heat and water stress, exceeded temperature thresholds and wildfires • Lower yields from dairy animals • Reduced labour productivity • Rise in market prices • Reduced biodiversity; species change for more resilient varieties may reduce nutritional value • Decrease livelihood assets	Decreased food availability, quality and variety reduces caloric and nutrient intake and increases acute, chronic and micronutrient malnutrition risk Increased risk of unsafe food and foodborne diseases Increased transmission risk for cholera Decreased soil and water quality reduces food yields Increased water stress and disaster risk reduces food yields and economic and physical access to quality and diverse foods Food staples have reduced nutritional value or become toxic Increased vulnerable populations due to climate-induced migration
Increases in sea-surface temperatures • Increased occurrence and duration of algal blooms/toxicity for food sources • Reduced availability of marine species • Increased contamination of seafood	
Sea-level rise • Damage to coastal fisheries • Loss of cultivable land by inundation, salinization and coastal erosion	
Gradual changes in precipitation patterns • Excess or shortage of water, changes in irrigation requirements • Water stress or flood risk for livestock, crops and vegetative cover • Some foods may be difficult to grow; introduction of new varieties • Local harvest losses certain, however, the geographic distribution of this is unknown • Changes in plant and animal diseases • Decreased livelihood assets • Salinization of water and soils • Increased contamination of agricultural crops (such as with mycotoxins)	
Glacial loss • Glacial fed river systems vulnerable to flooding and reduced flow rates • Mountainous valleys vulnerable to glacial lake outburst floods	
Greater weather variability • Greater uncertainty and instability of food supply, food prices; and agriculturally based incomes spur economic insecurity • Decreased accuracy in traditional knowledge and planting cycles lead to reduced yields and/or decreased diversity of local species • Altered ecology of plant, livestock, marine pests, diseases, vectors	
Increased frequency and intensity of extreme weather events • Damage to standing and stored crops, aquaculture facilities, loss of livestock, buildings, irrigation, equipment and other infrastructure • Loss and spoilage of stored crops and livestock feed, processing and food system resources • Increased soil erosion and decreased livelihood assets	
Increased atmospheric CO2 availability • Increased yield of food (mainly temperate regions) and plant biomass • Reduced nutrient content of crops, including protein and minerals • Levels of cyanide may increase in some crops (such as cassava).	

Care: Maternal and child care and feeding practices

High temperatures, extreme weather events, as well as stress and hardship of vulnerable households can all affect appropriate care and feeding practices. Breastfeeding is the recommended source of nutrition for newborns and infants. National-scale studies indicate that the impact of care and feeding practices on population malnutrition levels should not be underestimated *(58)*; for example, in 2016, suboptimal breastfeeding caused more than 150 000 deaths *(59)*. Poor early child care practices – including inadequate breastfeeding practices; inappropriate complementary feeding; poor access to or use of diverse types of food; and inadequate intake of micronutrients – directly contribute to poor child growth and malnutrition, all of which can be exacerbated by climate shocks and stresses.

For example, pregnant women and fetal health are vulnerable to extreme temperatures. Evidence supports the association between low birth weight and preterm and high environmental temperature, more specifically heat stress, which may be experienced during heat waves or following a sudden rise in temperature *(60–64)*. A warmer overall climate, with more frequent heat waves, prolonged drought and increased diarrhoea risk may result in increased risk of severe dehydration. Dehydration can be lethal in children; and maternal dehydration (hypernatraemia) during gestation can affect fetal growth *(65)* and the mother's ability to breastfeed.

Table 3 summarizes the impacts of climate change on care and feeding practices and the consequences for health and nutrition. An unstable climate compromises good care and feeding practices due to: periodic, but significant, reductions in food production; reduced community support mechanisms; migration from unproductive agricultural zones into potentially unsafe urban areas; and further increases in male seasonal migration, leading to increased female-headed households for long periods of the year with limited financial resources and a heavy domestic workload to provide food, water and income *(58,66)*. Heavy workloads for women have been shown to negatively affect infant and child care *(67)*. Maternal stress, lack of time or appropriate mother–child spaces, along with other factors can compromise antenatal care and good feeding practices, particularly during times of emergencies, displacement and increased domestic workloads, which inhibit appropriate feeding and care seeking. Additionally, the impacts of climate change on food safety and quality, with increased risk of food- and waterborne diseases for both mother and children, are likely to lead to impaired care and feeding practices and health and nutrition.

Table 3: Impacts of climate change on care and feeding practices, and resulting consequences for human health and nutrition

Climate impact and mechanism affected	Summarized consequences for health and nutrition
Increases in mean global temperatures and temperature extremes	Increased low birth weight and preterm births
• Dehydration and heat stress • Faster growth rates of microorganisms in food and water leading to increased risk of disease • Deteriorated hygiene conditions, increased food and drug spoilage	Increased risk of diarrhoea Dehydration related mortality/morbidity
Gradual changes in precipitation patterns	Compromised or disrupted appropriate caregiving and feeding practices for newborns and infants
• Increased labour migration and female workloads impact care practices	Inadequate access to feeding, caregiving, parenting support and resources
Increased frequency and intensity of extreme weather	Limited access to diverse, supplementary or fortified foods
• Feeding and caregiving promotion and support disrupted (maternal, household and community) • Disruption of breastfeeding, appropriate complementary feeding and hygiene practices • Decreased access to clean water, sanitation and hygiene for caregiving and feeding • Food safety compromised by water pollution and damage to stored food	

Health: Access to quality health services and a healthy and hygienic environment

There is a strong relationship between undernutrition, disease and access to health care; and climate change is likely to adversely impact this interaction both directly and indirectly. The linkages between disease and undernutrition are well established: the additional risk of stunting from non-food causes such as HIV/AIDS, acute respiratory infections, measles and malaria, and their interaction with food causes including diarrhoeal disease, further complicate malnutrition through various physiological mechanisms. The IPCC has also concluded with *very high confidence* that food- and waterborne disease risks will increase, further impacting nutrition as a consequence of warmer temperatures, extreme weather, and shifting precipitation patterns *(27)*.

Access to health services can be limited by extreme weather events that damage health facilities, infrastructure and commodities such as pharmaceuticals as well as nutritional, supplemental and therapeutic foods; render regular maternal and child health services unavailable; and cause families to lose economic access to health services or transport to utilize health services. Limited access to preventive and therapeutic care can accelerate the undesirable interactions of disease and undernutrition.

Table 4 outlines other less obvious linkages that may also exist between nutrition and a hygienic and healthy environment. For example, sea-level rise is affecting rates of maternal hypertension in deltaic regions, such as Bangladesh and Brazil, where saltwater intrusion increases sodium levels in drinking water, particularly in the dry season *(68,69)*. This may have ramifications for fetal health and birth weight, and present further complications for nutritional status.

Table 4: Impacts of climate change on underlying health status, access to quality health services, drinking water, safe food and hygienic environments, and resulting consequences for undernutrition

Climate impact and mechanism affected	Summarized consequences for health and nutrition
Increases in mean global temperatures and temperature extremes • Vaccine, pharmaceutical and nutritional supplement spoilage in high heat • Increased risk of food- and waterborne disease outbreaks • Preterm birth and low birth weight	Reduced access to effective care due to damaged or overburdened health care facilities Increased risk of heat stress, diarrhoeal diseases and dehydration
Sea-level rise • Salinization of drinking water compromises safe sources • Lost livelihoods, damaged coastal infrastructure including water/sanitation infrastructure, health facilities or access	Increased water stress/flooding; decreased water quality and hygiene; increased risk of food- and waterborne diseases and dehydration
Gradual changes in precipitation patterns • Unpredictable excesses or shortages of water • Increased risk of vector-borne diseases	Disaster risk for communities and health facilities
Glacial loss • Glacial fed river systems vulnerable to flooding and shortages • Mountainous valleys vulnerable to glacial lake outburst floods	Limited access and/or disrupted prevention and treatment of infectious diseases
Greater weather variability • Economic insecurity reduces access to water and health services	Reduced nutrient absorption due to disease
Increased frequency and intensity of extreme weather events • Decreased access to clean water, sanitation and hygiene • Loss, damage and disruption of health services and infrastructure reduces access to and use of health care and maternal and child health services, including nutrition-specific interventions, management of communicable diseases, pregnancy and childbirth • Increased need for treatment of severe acute malnutrition and nutrition interventions during emergencies	Limited availability and use of nutrition-specific interventions and programmes

These relationships, while presented as linear, are very dynamic and influenced by many internal and external factors. The ability of an agricultural system to produce a certain amount of food does not necessarily lead to appropriate nutrition of a population; nor does having inadequate agricultural yields necessarily lead to higher undernutrition rates. These relationships strongly depend on other aspects of the food system, such as trade and price dynamics. Thus, it is essential to analyse these variables with caution in the context of the entire system of the country or subregion, as well as disease burdens, behaviours and demographics of the examined population.

In conclusion, climate change will impact the foundations of good nutrition, yet social, behavioural and environmental opportunities exist to minimize the negative effects on nutrition. The nutrition sector's increasingly holistic perspective using targeted nutritional interventions *(70)* and nutrition sensitive interventions and programmes *(71)*, and supporting an enabling environment *(72)*, will be increasingly important. However, countries that have high levels of undernutrition and are prone to frequent climate-related disasters (such as floods and drought), should be actively integrating nutrition, health, agriculture and disaster risk reduction policies and interventions.

Additional resources:

Section 3 Resources in Annex 1 provides information on key reports providing background of current knowledge on linkages of climate change and agriculture, food security and nutrition.

Section 4

Identifying vulnerable populations

Basic research questions to answer in this step:

Which populations are most vulnerable to climate-exacerbated undernutrition?
What are the main conditions that make them vulnerable?
Are there particular regions or areas with high concentrations of vulnerability?
What are the major trends that may change population vulnerability in the future?

The first step of the analysis identifies subpopulations that are vulnerable to undernutrition associated with weather, current climate variability and recent climate change, along with factors that create their vulnerability. This step is fundamental to understanding who may be most affected by future climate change, why they may be affected and how to appropriately target preventive measures.

Populations highly vulnerable to undernutrition include malnourished populations, low birth weight babies, children under five years of age, adolescents, pregnant and breastfeeding mothers, older people, people with chronic illness, people living with a disability, urban populations, those living in poverty, subsistence populations and populations in countries at high risk of extreme weather events. These data should be disaggregated by district, climatic or agro-ecological zone, or rural/urban to identify the geographic distribution of demographic and health based vulnerability. Mapping tools can be useful.

The next step is to identify the nonphysiological/-demographic reasons for vulnerability, which may be behavioural, or due to social, economic, environmental and political conditions. For example, known risk factors for stunting include poverty and rural location *(73)*. Particularly, populations in drought-prone arid zones dependent on rain-fed agriculture may be highly vulnerable in the context of climate change. Table 5 outlines relevant factors that may determine vulnerability to climate-related undernutrition. These factors manifest at the individual, household, community to subnational levels. This analysis serves as the foundation for further steps in the assessment and can be relatively simple to implement using expert opinion, problem trees, conceptual and geographic mapping, and population data analysis (i.e. clustering or multivariate). It will be refined with quantitative data in later steps. Ranking populations by high, medium and low risk, or the relative importance of risk factors, can identify priorities. Men and women, boys and girls are shown to have different levels of vulnerability due to cultural perceptions of nutrition needs and resulting intra-household food distribution patterns *(66,74–77)*. Therefore, gender-analysis is of special relevance for climate, health and nutrition.

Current vulnerability is a strong indicator for future vulnerability. However, over time the geographic distribution of risk and vulnerability is likely to shift. Changing trends in population growth, urbanization, migration and socioeconomic growth will influence livelihoods, food security, variations in food prices and social protection mechanisms. Present trends relevant for future vulnerability should be noted in this step.

Table 5: Populations vulnerable to undernutrition and climate change

Category	Vulnerability factor	Reasons for vulnerability
Demographic factors	• Age (young and old) • Gender	• Elderly, infants and children physiologically susceptible to undernutrition • First "1000 days of life" crucial for mental and physical development
Biological or health factors	• Pregnant and lactating women • Populations currently suffering from seasonal or chronic malnutrition • Populations with infectious diseases and parasitic infections (e.g. diarrhoeal diseases) • Immunocompromised and HIV/AIDS affected populations • Populations with tuberculosis, chronic disease burdens, and mentally or physically disabled people	• Increased need for water and food • Underlying conditions predispose nutritional deficiencies or hinder treatment
Behavioural and cultural factors	• Child care and feeding practices • Nutritional knowledge • Food preparation • Eating habits • Intrahousehold food distribution patterns • Hygiene habits and knowledge	• Food consumption and utilization, energy and nutrient intake, and nutritional status compromised
Socioeconomic factors/ livelihood strategies	• Poverty • Displaced populations • Marginalized populations (i.e. ethnic minorities, nomadic and semi-nomadic populations) • Landless, migratory or indentured labourers • Agriculture-based livelihoods (on an individual and community scale) • Populations with nonresilient food systems and subsistence livelihoods (i.e. small-scale rain-fed farming, pastoralism) • Populations dependent on inland and coastal fishing, and aquaculture or forest-based systems • Populations with inadequate access to or use of health care • Occupation (formal vs informal sectors)	• Limited access to basic assets, such as health care, food, water and sanitation • Groups that may be discriminated against for ethnic, caste, gender or socioeconomic status • Sources of livelihood/access to sufficient, nutritious and safe food may be jeopardized by extreme weather and variable food prices, as small changes in food assets create large changes in consumption • Destruction of productive assets through risk of increased crop failure, loss of livestock and fish stocks and increasing water scarcities • Displaced populations lack resources, disrupted access to services and assets
Environment and sociopolitical factors	• Unhealthy environment: areas with poor water and sanitation access and use • Fragile ecosystems prone to natural disasters: coastal areas, floodplains, mountains, drylands and the Arctic • Marginal lands: areas with poor soil quality, ecosystem margins, and predicted to experience landscape/crop changes • Conflict zones and post-conflict zones • Urban vs rural	• Increased exposure, through water and food, to pathogens and tropical enteropathy; diminished opportunity for diagnosis and treatment • Decreased food availability will strain resources and increase malnutrition • Areas highly susceptible to environmental effects of climate change, resulting in livelihood asset diminishment • Diminished infrastructure and adaptive capacity • Diverse levels of assets and options

Additional resources:

WHO guidance on health vulnerability and adaptation assessment: Protecting health from climate change: vulnerability and adaptation assessment. Geneva: World Health Organization; 2013 (http://www.who.int/entity/globalchange/publications/Final_Climate_Change.pdf, accessed 18 November 2018) Section 2.2.5, for additional considerations of vulnerability.

See spatial map from El Niño and health (http://www.who.int/hac/crises/el-nino/who_el_nino_and_health_global_report_21jan2016.pdf, accessed 18 November 2018); ping tools and examples can be found in the guidance (page 17).

Section 5

Establishing baselines

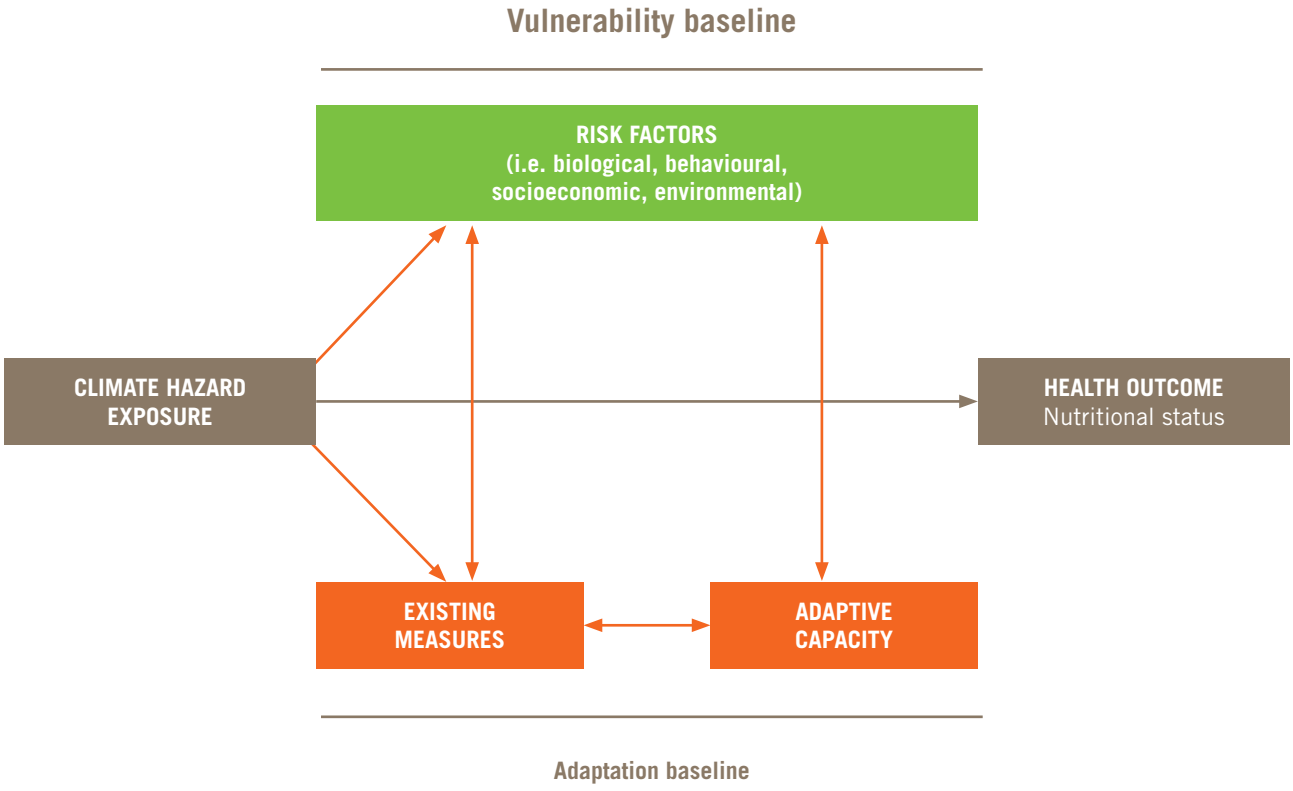
Basic research questions to answer in this step:

What is the current nutritional situation?
What conditions persist which determine this nutritional status?
What are the average and extreme climatic conditions?
What are the current programmes and policies that protect human nutrition?
In what ways do communities and institutions prepare for and cope with crises or food insecurity?

The V&A baseline is a situation analysis, or snapshot of the current conditions that determine the nutritional status of the population using qualitative descriptions and quantitative metrics. The baseline is a tool that helps examine why undernutrition exists, and the relative importance of different conditions in causing and reducing the prevalence of undernutrition. As multiple factors drive good nutrition or undernutrition, the best baselines will be constructed using a range of indicators and information from a variety of sectors through a multidisciplinary approach. A comprehensive baseline should reflect current nutrition realities, and be structured to allow for monitoring changes in food and nutrition security, principle risk conditions and response capacity over time. The baseline is also essential for later steps of the assessment where predictive models and scenarios of future conditions are created, based on local information. A baseline aims to capture "normal" conditions. Thus, data that may reflect abnormal or crisis conditions must absolutely be noted (such as baseline set in an El Niño–Southern Oscillation (ENSO) year or post-crisis situation) so that future monitoring and research can appropriately recognize these biases. Since including too many indicators in the baseline may complicate future monitoring, each country may decide to select just some key indicators.

Relevant statistics and qualitative information could be gathered to describe each of the following categories shown in Figure 2. These include: climatic conditions the population is exposed to; risk factors which determine vulnerability and may be modified by climate and interventions; existing policies and measures which modify outcomes; adaptive capacity to cope with future risks; and the health outcome, i.e. nutritional status.

Figure 2: Key information categories to include in the climate and nutrition baseline



Specifically for a climate and nutrition baseline, it is important to obtain a good understanding of the following dimensions:

i. **Exposure to climatic hazards** – reflecting historical averages and extreme climate conditions affecting the study area (such as temperature and precipitation patterns, type, frequency and magnitude of extreme weather events that affect food security and determine household diets). Climate conditions should be described in the context of local agriculture and hydrology, noting other relevant environmental conditions related to climate (such as erosion, pests, irrigation). Descriptions of past extreme events and the type of impacts observed on nutrition can be helpful.

ii. **Risk factors** – **(a) Food security:** capturing key socioeconomic and environmental elements determining the current food system and its security, reflecting subcategories of food availability (such as production, quality, food aid, imports), access (such as purchasing power, food price indices), utilization (such as diet composition and consumption patterns) and stability (such as food price variability). Useful descriptions may include known causes for undernutrition and volatility; seasonal food security calendars; and when and why seasonal or catastrophic variations in nutritional status may occur. **(b) Care and feeding practices:** capturing relevant socioeconomic and behavioural determinants of nutrition (such as infant and young child feeding practices, child health care seeking behaviours, levels of nutritional knowledge, intrahousehold food distribution). **(c) Access to health services and healthy environments:** capturing access and use of adequate water, sanitation and quality health services.

iii. **Existing measures** – reflecting effectiveness of current health services, nutrition specific and sensitive (i.e. multisectoral) policies and measures to protect nutrition (such as national nutrition priorities, health care access and coverage; preparedness levels to address crises; economic and social protection resources; as well as local customs and coping mechanisms for maintaining good health during lean seasons or food shortages).

iv. **Adaptive capacity** – reflecting community and health system capacity to respond to change (such as possible increases in undernutrition incidence) and adapt in ways that will counter and manage increasing vulnerability to undernutrition. This may include preparedness, capacity to anticipate and mitigate crises, agricultural and water policies that enhance community resilience, and the humanitarian context.

v. **Health and nutrition status** – reflecting the ultimate outcome of interest (undernutrition) and immediate causes of undernutrition related to disease (i.e. diarrhoeal disease), particularly of infants and children under five years of age and women of childbearing age. Indicators for other health conditions exacerbated by undernutrition, such as HIV, acute respiratory infections, measles, and malaria, should also be reflected.

Sex disaggregated anthropometric data of infants and children under the age of five years should be amongst the first data collected. It is recommended that baseline data for at least a 10-year period be used for longitudinal analyses in later steps of the assessment.

This principle step of the assessment collects a vast amount of secondary data. An indicator framework can be useful to organize, understand and monitor these conditions over time. It is recommended that key metrics (i.e. three to six principle indicators) are selected to summarize baseline information categories and provide a quantitative "snapshot" of current nutritional vulnerability to climate change, at the desired scale (national, provincial, district level). Selection criteria for key indicators will vary, but ideally the chosen metrics should be easily measured through existing primary (such as multiple indicator cluster surveys (MICS), demographic and health surveys (DHS)) and secondary mechanisms (such as FAO-Food Security Statistics, WHO-Nutrition Landscape Nutrition Information System (NLIS), WHO/UNICEF Joint Monitoring Programme for Water Supply, Sanitation and Hygiene (JMP)). These indicators could be presented in conjunction with descriptive contextual information about behavioural, social and environmental factors that drive the observed geographic and spatial distribution of undernutrition within the population. It is however not necessary to analyse all these outcomes. Some examples of common indicators to consider using to represent these categories and potential sources are included in Table 6 and in the annex for section 5.

The completed baseline should then be analysed and refined to answer key questions, such as: *How many, and which subpopulations are affected by, and vulnerable to, different types of undernutrition? What are the main causes for their vulnerability? What kind and magnitude of climate stress and shocks are currently experienced? How may decisions in other sectors influence these outcomes?* Cross-tabulations, regressions and multivariate analyses can provide insights into the primary factors that affect food security and nutrition status.

Table 6: Useful metrics for understanding and monitoring the effects of climate change on nutrition

Vulnerability factor	Metrics relevant for nutrition	Data sources to consult
(i) Climate hazard exposure	Average monthly precipitation for the past 10 years (longer if available) Average monthly minimum and maximum temperatures for the past 10 years (longer if available) Mean annual temperature increase rate/time period Proportion of rainfall occurring in heavy events [a] Number and magnitude of extreme weather events which damaged crops or waterways that affected agricultural productivity (i.e. high temperatures, drought, windstorms, flooding, frost anomalies) Influence of El Niño–Southern Oscillation (ENSO) events	WHO/United Nations Framework Convention on Climate Change (UNFCCC) Climate and Health Country Profiles UNDP Country Climate Change Profiles World Bank Climate Portal Pacific Climate Change Science Country Brochures Caribbean Health – Climatic Bulletin
(ii) Risk factors *(a) Food security*	***Food availability and access*** % population below minimum level of dietary energy consumption (undernourishment) Dietary energy consumption disaggregated by gender (kcal/person/day) Share of the total dietary energy consumption (%) from eight major food groups: cereals, milk, meat, sugar, vegetable solids, fruits, vegetables, starchy roots Cost ratio of a minimum daily food basket to the average daily income Poverty gap ratio at US$ 1.25 a day purchasing power parity Income diversification: household food production vs nonfarm income sources Number of low-to-medium income groups who may lose homes, store food, personal possessions and means of obtaining livelihoods Proportion of population receiving food aid Ratio of locally produced vs imported food products Average proportion of household income used for food purchase Magnitude and proximity of local and regional food storage, relative to demand.[a] Gender equity in food access: women's energy consumption during food crisis Change in food consumption by women, men, boys and girls per quarter (source could be a household or nutritional survey) Change in the amount of milk, eggs, fish and animal protein consumed by household family members disaggregated by women, men, boys and girls (sourced from child health records or household or nutritional survey; Household Food Insecurity Access Scale for Measurement of Food Access)[b]	WHO – NLIS FAO Statistics Division Data WHO estimates of the global burden of foodborne diseases World Bank Data UN Sustainable Development Goals Indicator Database

Vulnerability factor	Metrics relevant for nutrition	Data sources to consult
	Food utilization and stability	
	Household Dietary Diversity Score[c]	
	World Food Programme Food Consumption Score (particularly for emergency and disaster situations)[d]	
	% of households consuming adequately iodized salt, i.e. 15 parts per million or more	
	Prevalence of foodborne diseases; and incidence of foodborne disease outbreaks	
	Proportion of girls and boys enrolled in school feeding programmes [a]	
(b) Care and feeding practices	***Infant and young child feeding practices*** [e]	WHO – NLIS
	Proportion of infants under six months of age who are exclusively breastfed	UN Sustainable Development Goals Indicator Database
	Proportion of infants aged 6–8 months who receive solid, semi-solid or soft food	
	Proportion of children aged 6–23 months who receive a minimal acceptable diet (including foods from four or more food groups)	
	% Women aged 15–19 years who are mothers or pregnant with their first child	
	Health care access and seeking behaviour	
	% births attended by skilled health personnel	
	% children one year of age immunized against measles	
	% children with diarrhoea who receive zinc	
	% women receiving daily iron (60 mg) and folate (400 µg) supplements during pregnancy	
	% children aged 6–59 months who received at least one high-dose vitamin A (% receiving dose 2)	
(c) Access to health services and healthy environments	***Health service capacity and access***	WHO – Universal Health Coverage Data Portal
	Density of hospital beds (per 10 000 population)	
	Density of physicians (total number per 1000 population)	UN Sustainable Development Goals Indicator Database
	Access to essential medicines	
	Water, sanitation and hygiene	WHO – NLIS
	Proportion of population with sustainable access to improved drinking-water sources	WHO/UNICEF Joint Monitoring Programme Data
	Proportion of population with sustainable access to improved sanitation	World Bank Data
	Number of households with a specific place for hand washing where water and soap are present	
	Environmental conditions	
	Type and number of algal blooms, cyclones or floods that reduced aquaculture yields or available species	
	Proportion of agriculture rain-fed vs irrigated	
	Annual freshwater withdrawals, total (billion cubic metres)	
	Agricultural irrigated land (% of total agricultural land)	
	Prevalence and impact of agricultural pests and disease	

Vulnerability factor	Metrics relevant for nutrition	Data sources to consult
(iii) Existing measures	***Nutrition specific interventions (location specific) interventions***	Global database on the Implementation of Nutrition Action (GINA)
	Proportion of children with severe acute undernutrition having access to appropriate treatment including therapeutic foods.	WHO Strengthening surveillance of and response to foodborne diseases
	Number of health workers with nutrition skills at each level of service delivery	WHO/United Nations Framework Convention on Climate Change (UNFCCC) Climate and Health Country Profiles
	Nutritional surveillance and early warning systems identify and initiate appropriately early action	
	Reliability, capacity and failure trends in energy, communications and health care services responsible for providing nutrition specific interventions[f]	
	Spatial distribution and prepositioning of emergency supplies and nutritional products ensure availability in crisis situations[f]	
	Emergency nutrition plans consider a range of climate conditions[f]	
	Availability of ready-to-use therapeutic food during food crises	
	Nutrition-sensitive (location specific) interventions	
	% of bio-fortified crops in areas of high micronutrient deficiencies	
	Number of children under five years of age with diarrhoea in the previous two weeks who received oral rehydration therapy (oral rehydration solution packet or recommended homemade fluid or increased fluids) and continued feeding during the episode of diarrhoea	
	Coverage of school feeding programmes	
	Climate change/disaster risk reduction policies and programmes consider food and nutrition security	
(iv) Adaptive capacity	***Enabling environment***	WHO – NLIS
	Strength of nutritional governance (NLIS, Global Nutrition Policy Review Survey)	GINA
	National legislation and adaptation strategies for climate and health, and/or food security and/or food safety, includes food safety and nutrition	
	Health and nutritional services have assessed their future performance in light of projected climate change[f]	
	Performance information is collected and analysed, and lessons learned are incorporated into policy and programming[f]	
	Community coping mechanisms	
	Reported availability and consumption of famine foods	
	Multiple options for delivering services available to reduce dependency on single sources of services (such as availability of community-based treatment of severe malnutrition)[f]	
	Mechanisms in place for community based organizations and services to coordinate and communicate adequately with formal health services[f]	
	Mechanisms in place to counter supply failures in pharmaceuticals, nutritional products and food supplies[f]	

Vulnerability factor	Metrics relevant for nutrition	Data sources to consult
(v) Health and nutritional status	***Infants and children under five years of age*** Child mortality rate (of children younger than five years of age) % stunted children (height for age) below two standard deviations (of WHO Child Growth Standard median) (including moderate/severe stunting) % children wasted (weight for height) below two standard deviations (of WHO Child Growth Standard median) classified by global acute malnutrition, moderate acute malnutrition and severe acute malnutrition Proportion of newborns (x 1000 live births) with low birth weight (<2500 g) ***Adolescents and adults*** Body mass index (BMI) – % adult population below the benchmarked rate of 18.5 ***Coinfection rates*** Intestinal helminthic infection rates Prevalence and incidence of diarrhoeal disease HIV/AIDS prevalence ***Micro-nutrient deficiencies in women and children*** Prevalence of anaemia in women of reproductive age Prevalence of anaemia in pregnant women (haemoglobin concentration below 110 g/l at sea level) % clinical vitamin A deficiency in women clinically (spectrum of ocular manifestations) subclinically (<0.70 µmol/l plasma retinol concentration) % population with iodine deficiency (median urinary iodine concentration of a population <100 µg/l)	WHO – NLIS GINA UN Sustainable Development Goals Indicator Database

a Defined as a daily rainfall total which exceeds the threshold that is exceeded on 5% of rainy days in the current climate of that region and season.

b Household Food Insecurity Access Scale (HFIAS) for measurement of food access: indicator guide https://www.fantaproject.org/monitoring-and-evaluation/household-food-insecurity-access-scale-hfias, accessed 29 November 2018.

c The indicators to monitor the implementation of the comprehensive implementation plan can be found at http://www.who.int/nutrition/EB128_18_backgroundpaper4_nutrition_indicators.pdf, accessed 29 November 2018.

d Technical guidance sheet – food consumption analysis: calculation and use of the food consumption score in food security analysis. https://www.wfp.org/content/technical-guidance-sheet-food-consumption-analysis-calculation-and-use-food-consumption-score-food-s, accessed 29 November 2018.

e See description of all eight core IYCF Indicators here: Indicators for assessing infant and young child feeding practices: conclusions of a consensus meeting held 6–8 November 2007 in Washington DC; 2008 (http://apps.who.int/iris/bitstream/handle/10665/43895/9789241596664_eng.pdf, accessed 29 November 2018).

f Selected indicators of resilience modified from: Climate resilience and food security: a framework for planning and monitoring. 2013 (https://www.iisd.org/sites/default/files/publications/adaptation_CREFSCA.pdf, accessed 16 November 2018) *(78)*.

Additional resources:

See section 2.2 of the V&A guidance for additional guidance on measuring current conditions. Resources for section 5 suggest relevant global datasets, such as the FAOSTAT (food and agriculture statistics), WHO, UNICEF and the World Bank databases that provide useful country profiles, allowing for a range of aggregated variables related to nutrition to be quickly gathered, and identify the types of data to be sourced elsewhere. Notably, the WHO has aggregated key national level nutrition data from UN and partner organizations, in the NLIS.

The Global Database on the Implementation of Nutrition Action (GINA) provides country-level overviews on measures to increase food security. For further considerations on measuring resilience of the food system see "Qualitative data and subjective indicators for resilience measurement" by the World Food Programme (http://www.fsincop.net/fileadmin/user_upload/fsin/docs/resources/1_FSIN_TechnicalSeries_4.pdf, accessed 29 November 2018). While providing valuable information on the generalized status of the entire country, the subnational and local trends may not be reflected.

National household surveys (e.g. DHS, MICS) and other instruments should be sourced through national statistics agencies, development agencies, research institutes for disaggregated subnational data. Community level surveys or other qualitative instruments may be necessary to compile the baseline data.

Section 5 Resources in Annex 1 includes datasets and indicators useful to construct national and subnational vulnerability baselines.

Section 6

Assessing the sensitivity of nutrition to climate

Basic research questions to answer in this step:

How do average, seasonal and extreme climatic conditions influence the burden of undernutrition? What are the current programmes and policies that protect human nutrition? In what ways do communities and institutions prepare for and cope with crises or food insecurity?

This step of the study examines the climate sensitivity of nutrition, or the degree to which climate determines the occurrence and spatial distribution of undernutrition. The degree to which population nutrition responds to diverse climatic conditions depends on many complex nonclimatic factors. The relationships between nutritional outcomes and core weather variables, such as average temperature, precipitation and extreme weather events can be explored. However, careful analysis and judgement is needed, and caution should be exercised when interpreting correlations of indirect causality such as nutrition, particularly from low-resolution data. Table 7 outlines key climatic variables and climate-sensitive risk factors that can be analysed.

Sensitivity studies are ecological studies in the epidemiological sense, which investigate population scale relationships through spatial or temporal variation in exposure and outcome. Notably, empirical studies of climate and health impacts have made important insights about calculating these relationships, and caution that simplistic models may be misleading. The general considerations for conducting sensitivity studies are that they should ideally: (i) be based on local meteorological data at high temporal and spatial resolution (such as daily or weekly data from local meteorological stations); (ii) use anthropometric and health data based on standardized diagnostic criteria that are comparable over time, and be representative of the study population (such as national health surveillance services for countries or large areas, or from specific sites such as hospitals); and (iii) have a control for the effects of nonclimatic seasonal variations *(79)*.

Table 7: Sensitivity of nutritional risk factors to climate

Environmental change	Key risk factors for undernutrition				
	Availability of sufficient, nutritious and safe food	Economic or physical access to sufficient, nutritious and safe food	Food safety and quality	Maternal and child care and feeding practices	Diarrhoeal disease
Daily temperature	X	X	X	X	X
Extreme temperature/temperature threshold	X	X	X	X	X
Daily precipitation	X		X		X
Extreme precipitation: flooding, drought, storms, land slides	X	X	X	X	X
Humidity	X		X		X
Sea-surface temperatures	X		X		X
CO_2 concentration			X		

Different approaches can be used to identify statistically significant associations of undernutrition and sudden, periodic or long-term changes in climatic conditions. It is advised to examine associations beyond averages. Investigation of relationships between undernutrition incidence, the extreme values of key variables (such as extreme weather events), and/or the observation of seasonal and geographic variation is highly indicative of climate sensitivity; particularly the patterns described below.

- **Extreme weather events (weather anomalies or inter-annual variability)** can disrupt agriculture, trigger acute nutritional crises, promote or inhibit disease transmission (including food- and waterborne), and cause striking temporal changes in the nutritional status of affected populations. These events can be isolated in time, generally last days, weeks or months and represent a marked set of environmental conditions. Notably, wasting and microdeficiencies may be associated with short duration phenomena; stunting will not be associated with single events, although the influence of repeated extreme events may be observed.
- **ENSO** is a climate event that originates in the Pacific Ocean on a quasi-periodic basis (every three to eight years) with wide-ranging consequences for weather around the world. ENSO affects regional rainfall patterns and alters the intensity of floods and droughts. Particularly in regions with high dependence on rain-fed agriculture, impacts on food security can be severe. Furthermore, ENSO affects the transmission of diarrhoeal, vector-borne and rodent-borne diseases, the incidence of seafood poisoning, and may provoke the disruption of health services *(80)*. Historic ENSO years are listed in the resource section, and should be accounted for appropriately in the sensitivity analyses.
- **Seasonal trends** are expected in climate-sensitive health conditions, especially those with short development periods *(81)*. This may result in high-risk and low-risk periods. Locals and medical personnel should be aware of the seasonal patterns. Temporal analysis can help identify, for example, the timing of a "lean season" prior to harvesting when higher rates of undernutrition may be observed. Or, such as in the Gambia, where a peak in undernutrition is observed immediately following the epidemics of bacterial gastroenteritis during the rainy season, but is not associated with the cool dry season rotavirus outbreaks *(82)*.

- **Geographic variation** is expected in key climate and outcome indicators where local microclimates and changes in altitude or place-based vulnerabilities may significantly affect local agriculture, exposure to climate hazards, cultural feeding practices, onset of seasons, among others. Spatial analysis can reveal important associations between environment, climate and nutritional outcomes.

Additional resources:

See sections 2.2.3 – 2.2.5 of the V&A guidance for additional recommendations for conducting sensitivity and trend analysis. Existing national climate assessments and the National Meteorological Services in your country should be primary sources for national and subnational climate data. Section 6 resources include additional sources of current and historical meteorological data, including ENSO years, and national hazard calendars indicating harvest and lean season relations to climate events.

See also Atlas of Health and Climate (http://www.who.int/globalchange/publications/atlas/report/en/, accessed 29 November 2018), section 2 on emergencies (drought, floods and cyclones). This section offers a complete panoramic of the geographical relationship between nutritional outcome and weather variables.

Section 6 Resources in Annex 1 includes data sources and relevant information on climate variables to assist with sensitivity analysis.

Section 7

Anticipating future risks and impacts

Basic research questions to answer in this step:

How will the predicted changes in climate and other factors affect future nutritional status (in the study area)?
How far into the future are these changes expected?

The impacts of climate change on nutrition that may occur in a particular location will depend on the actual climate change experienced, future socioeconomic development of the area that is driving the true vulnerability of the community and region, and the actions in place to protect health, food security and nutrition. Thus, constructing future scenarios of nutritional security is a complex task, and the qualitative and quantitative approaches used will depend on the data and resources available to the study, and the decision needs for understanding future risks.

The assessment should aim to cover the timeframe of decision needs, and position these decisions within long-term climate and food security conditions. For example, **operational planning needs** may require short-term projections (such as seasonal and intra-annual scale influences of climate variability), to inform early warning systems or emergency planning. **Long term adaptation planning and research** may require long-term (20–100-year) projections, to understand systemic changes in the food system, landscape and society. A single time value, i.e. 2020 or 2050, is adequate if the aim is to show what can happen in different parts of the country over time. However, three time periods (i.e. 2015–2025, 2026–2050, 2051–2080) should be chosen if the aim is to show at what time and to what degree various adaptive measures need to be implemented *(83)*. When trying to understand how the climate may change at the national or subnational level, it is advised to consult the national climate authorities and use the same climate scenarios and timeframes as used for UNFCCC national climate communications or other studies, to encourage compatibility. Trade-offs are also to be expected between the kinds of information available from climate models (which are better at predicting interdecadal trends rather than year-to-year variation), projections of socioeconomics, water and agriculture (which tend to be more accurate in the short rather than the long term) and the time horizon of decision-makers that is often only a few years into the future.

Both quantitative and qualitative methods can be used. However, as the impacts of climate on nutrition are indirect and complex, qualitative scenarios may be the most useful way to begin identifying how risk factors may evolve over time. For quantitative modelling, long-term projections will often use baseline data to model how key factors determining nutritional security (such as agricultural productivity, per capita calorie consumption, or disease rates) may evolve in the absence of climate change, accounting for factors such as economic growth rates, future investments in programming, water availability, population dynamics and current levels of disruption from extreme events. Then, assuming that exposure–response relationships remain constant, apply new information on how the climate is likely to change the principle risk factors in the study area (i.e. increased frequency of

flooding), apply the sensitivity analysis factors (i.e. flooding increases seasonal undernutrition by x%) to extrapolate future conditions.

For both approaches, existing projections should be used for reference, noting that current long-term predictions of the effect climate change will have on undernutrition are based predominantly on projected national agricultural outputs related to food availability and undernourishment. Nelson and coworkers *(84)* projected regional distributions of undernutrition in 2050, with and without climate change. They estimate that in 2050, calorie availability will be lower than scenarios with no-climate-change, and even lower than 2000 levels throughout the world; and report that calorie availability for the average consumer in developing countries, may even be 10% lower than 2000 levels. Table 8 describes the projected number of undernourished and stunted children under five years of age for both scenarios – with and without climate change. Projections by WHO estimated an additional 3.6 million moderately and 3.3 million severely stunted children under five years of age in South Asia and sub-Saharan Africa *(32)*. A more recent Lancet study also estimated overall reductions in food availability under climate change and found that changes in diet composition, such as reduced fruit and vegetable and meat consumption are likely. This model estimated that the health effects from these dietary changes are associated with 529 000 climate-related deaths globally, outlined in Table 9 *(85)*. While reduced food production will likely increase the negative health effects of undernutrition, it must be emphasized again that there are many internal and external factors that influence this relationship, including economic trade, care practices and health. Your study should aim to further refine the resolution of such projections, using similar or diverse methods, for the study area. A range of additional considerations may be relevant and should be explored. For example, population migration trends, conflict or how the regional-scale changes in agriculture or trade could have cross-border consequences on local food security.

Table 8: Projected number of undernourished children under five years of age (in millions) in 2000 and 2050 with climate change.

Scenario		South Asia	East Asia/ Pacific	Europe and Central Asia	Latin America and Caribbean	Middle East/ North Africa	Sub-Saharan Africa	All developing countries
2000		75.6	23.8	4.1	7.7	3.5	32.7	147.9
2050	No climate change	52.3	10.1	2.7	5.0	1.1	41.7	113.3
	Climate change	59.1	14.5	3.7	6.4	2.1	52.2	138.5

Source: IPCC Fifth Assessment Report, 2014 *(27)* (Adapted from Nelson et al., 2009) *(84)*

Note: Results assume no effect of heat on farmers' productivity, and no CO_2 fertilization benefits.

Region	Climate change-attributable stunting (millions of children below five years)						
	Stunting level	Base case		Low growth		High growth	
		2030	2050	2030	2050	2030	2050
sub-Saharan Africa	Moderate	0.8 (0.4 – 1.1)	1.8 (1.6 – 2.1)	0.4 (-0.06 – 0.8)	-2.6 (-3.0 – -2.1)	0.7 (0.4 – 1.1)	1.2 (1.0 – 1.4)
	Severe	2.3 (2.0 – 2.6)	2.4 (2.2 – 2.5)	2.9 (2.6 – 3.2)	3.9 (3.5 – 4.3)	1.9 (1.7 – 2.2)	1.1 (9.7 – 1.2)
Asia, south	Moderate	1.1 (0.6 – 1.6)	1.8 (1.6 – 2.1)	1.1 (0.6 – 1.6)	-1.5 (-2.1 – -0.9)	1.1 (0.8 – 1.5)	1.3 (1.1 – 1.5)
	Severe	0.9 (0.6 – 1.3)	0.9 (0.8 – 1.0)	1.4 (0.9 – 1.9)	2.1 (1.2 – 3.1)	0.6 (3.5 – 0.9)	0.2 (0.1 – 0.3)

Table 9: Estimated number of climate-related deaths (thousands) in 2050 with climate change (mean)

Scenario	LMICs[a] of Africa	LMICs of the Americas	LMICs of the Eastern Mediterranean	LMICs of Europe	LMICs of Southeast Asia	LMICs of the Western Pacific	High income countries	Global
2050 with climate change (mean)	27.69	2.67	12.36	14.34	163,52	264.27	38.47	528.71

Source: Springmann M, Mason-D'Croz D, Robinson S, Garnett T, Godfray HCJ, Gollin D, et al. Global and regional health effects of future food production under climate change: a modelling study. Lancet 2016;387:1937–46 *(85)*.

a low- and middle-income countries

Next steps and resources:

See V&A guidance, section 2.3 for further information and examples (Box 16 and 17) on how to establish a projection using both qualitative and quantitative approaches.

Section 7 Resources in Annex 1 includes links to existing projections of climate impacts on food security and malnutrition; as well as relevant data sources to project future changes to food security and malnutrition at the national and subnational scale.

Section 8

Identifying adaptation options

Basic research questions to answer in this step:

What adaptation measures can be implemented to mitigate the impacts of climate variability and change on the burden of undernutrition?
Which adaptation options should be prioritized?

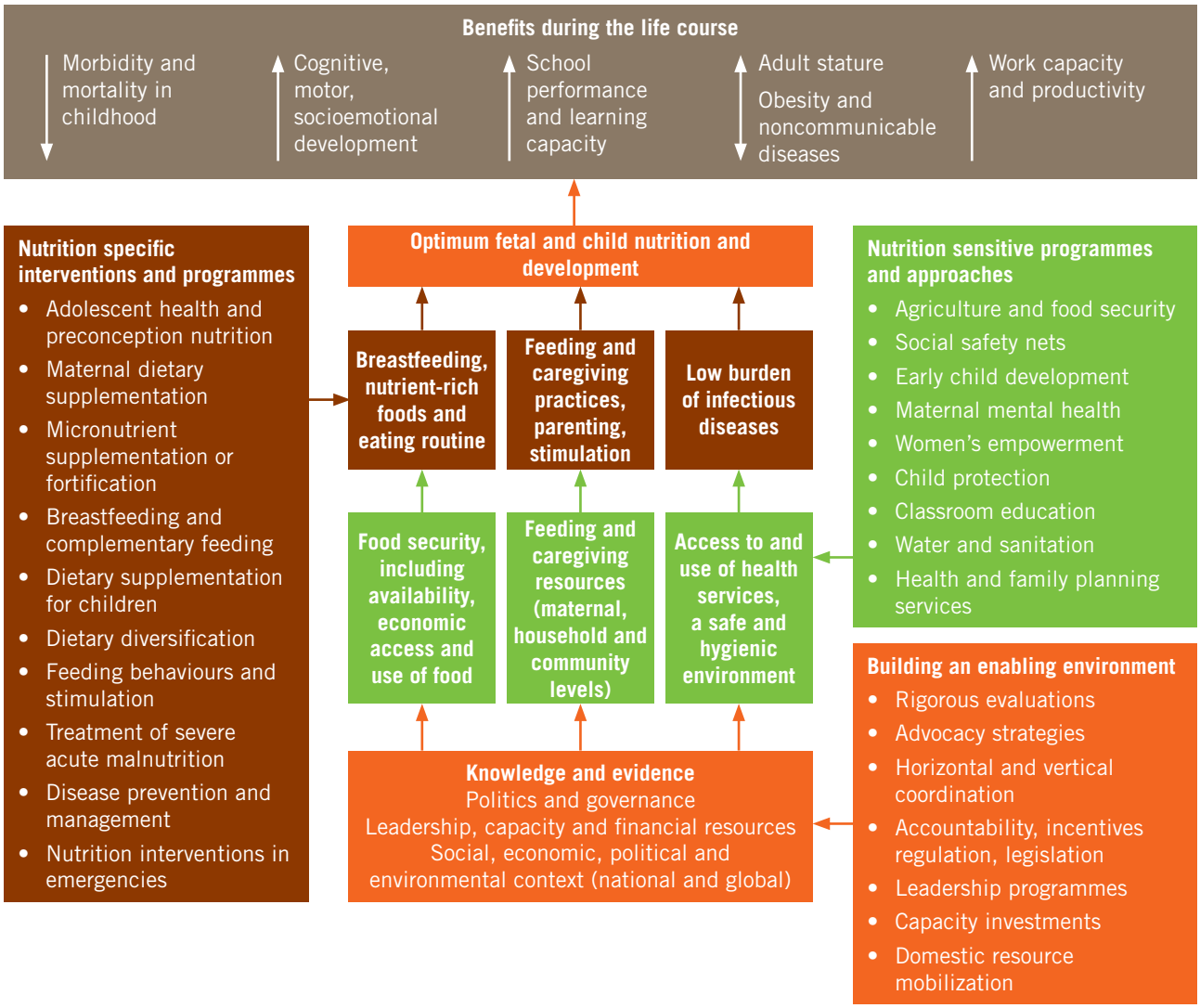
The identification of adaptation options is based on judgements about whether current and planned policies and programming would be adequate to manage the identified potential shocks and pressures on nutrition. Standard approaches for policy analysis and measuring programme coverage and efficacy can be used to answer questions such as*: Do coverage gaps and vulnerabilities in certain geographic areas exist? How will health and nutrition services perform under diverse climate shocks and stresses? In which contexts could failures be expected? Are specific vulnerable populations underserved or would they be unprotected from the impacts of extreme events? Are there times of the year that may require additional programmatic support or more intensive monitoring? Up to what point will current capacities and approaches be sufficient to manage the magnitude of projected climate impacts on nutrition?* This step of the study would be most effective if decision-makers and practitioners familiar with available and current interventions are involved.

Once impacts have been identified at appropriate spatial and temporal scales (now, in five years, 10 years, 20 years), all possible adaptation policies and programmes should be identified, and then screened for feasibility and prioritized. Some of the most important protective measures may be general (such as poverty reduction), and many may occur in other sectors. Specific interventions (as shown in Figure 3) should be evidence-based and adhere to international and national nutrition standards. Interventions can be selected from recommendations for: essential nutrition actions *(86)*; nutrition-specific interventions *(36,70)*; nutrition-sensitive interventions (such as those that enhance agriculture and food security, provide social safety nets, water and sanitation, or women's empowerment) *(45)*; and investments in the enabling environment through leadership, legislation and capacity that have been shown to be effective *(46)*. However, identifying adaptation options is not simply about implementing "more of the same". In order to address the issues presented by climate change these interventions should be designed to be: futuristic and pro-active; responsive to new knowledge about climate-sensitivity and vulnerability of nutrition generated from this study; informed by trends and information about the climate, food security and the environment; ensured to increase food access and improvement in socioeconomic conditions; and be increasingly flexible to respond to changes and unexpected challenges *(28)*. Understanding how gender dynamics determines nutritional outcomes will also be critical to the design of effective interventions *(75)*.

Nutrition programming can become more climate-responsive by strengthening climate considerations in areas of: leadership and governance; workforce; vulnerability, capacity and adaptation assessments; integrated risk monitoring and early warning; research; management of environmental determinants of

health and nutrition; emergency preparedness and management; and finance *(36)*. The WHO guidance to protect health from climate change through health adaptation planning provides further information on how to integrate health and food security adaptation in the National Adaptation Plan process *(87)*.

Figure 3: Framework for actions to achieve optimum child nutrition and development



Source: Black *et al.*, 2013 *(5)*

Table 9 summarizes specific nutrition adaptation options recommended by the UN System Standing Committee on Nutrition (UNSCN). These adaptation options have been structured using the categories included in the *WHO Operational framework for building climate resilient health systems*, which provides further information and guidance on how to develop comprehensive health adaptation plans *(88)*.

As a reminder, for solutions to be locally and culturally appropriate and effective, communities themselves must be involved in the design and implementation. Women in particular should be consulted to understand the customary diet, feeding habits, nutritional needs, food preparation and hygiene habits *(74)*. It is also important to remember that urban and rural areas differ in available options at the household level; and adequate and environmentally sustainable energy and water are necessary requirements for food preparation and hygiene.

Table 9: Climate change adaptation options for nutrition

Building block and resilience component	Examples
Leadership and governance	
Leadership and governance	• Ensure nutrition is addressed in climate resilient development and national climate change processes, plans and programmes (such as National Adaptation Plans (NAPs), National Communications and Nationally Determined Contributions). • Increase policy coherence and multidisciplinary collaboration at local, regional, national and international levels to enhance food chain sustainability and local access to adequate nutrition. • Promote rights of vulnerable people to essential livelihood resources, including land rights and access to or protection of fishing grounds. • Promote the use of nutritional outcomes as indicators of agriculture, health, social protection, education, water supply and sanitation, gender equality, governance and state fragility. • Promote cross-sectoral communication to align adaptation actions in agriculture or infrastructure (such as increasing water, sanitation and hygiene (WASH) coverage) with adaptation within the health sector. • Promote national commitment to shift towards healthy, sustainable diets. • Empower and link local-level voices, experiences and expertise to the national and international climate change agendas. • Ensure strengthened legal rights and equal access to resources for both women and men.
Health workforce	
Health and nutrition workforce	**Capacity development** • Raise awareness on nutrition and climate change among decision-makers and policy-makers. • Build clinical and community-based management capacity of undernutrition. • Health personnel trained in the use of climate information and early warning systems. • Promote gender equality and girls' education. • Support the development of strong institutional frameworks and human resources to implement nutrition-based agendas.
Health information systems	
Vulnerability, capacity and adaptation assessment	• Refine the understanding of potential impacts of climate variability and change on national nutrition, including for high-risk populations and areas, and seasonal/acute nutrition risks. • Identify the effectiveness of interventions to promote community level nutritional resilience to climate change. • Conduct participatory, nutrition-focused risk assessments and risk reduction plans. • Identify and target interventions to support particularly vulnerable groups, especially young children and pregnant and lactating women. • Specifically identify and address gaps regarding the nutritional status of adolescent girls and women prior to conception and inter-pregnancy intervals.
Integrated risk monitoring and early warning	• Strengthen surveillance systems of infectious disease, including surveillance and control of food hazards and foodborne disease and relevant environmental determinants (such as WASH) by food control and health authorities. • Improve the use of nutrition early warning/early response systems (including sentinel and community nutrition surveillance) by the health sector. • Ensure use of seasonal calendars for sentinel targeting.

Building block and resilience component	Examples
Health, nutrition and climate research	• Improve the understanding of climate linkages to the determinants of undernutrition. • Identify potential regional and local hotspots for undernutrition in 2020, 2030, 2040, and so forth. • Explore, test and scale-up nutrition-sensitive climate mitigation strategies that bring cobenefits in terms of enhanced production of and access to food. • Improve evidence to determine which climate mitigation actions have a negative effect on nutrition security and why, and identify alternative nutrition-sensitive solutions. • Understand the appropriateness of social protection programmes, such as cash and vouchers programmes for food and nutrition insecure households. • Research and development programmes for the breeding of selected crops and livestock with enhanced nutritional quality and resistance to climate variability.
Essential medical products and technologies	
Climate resilient and sustainable technologies	• Ensure agricultural extension services are used to promote better crop diversity and biodiversity for improved nutrition, with an emphasis on vegetables and fruits. • Integrate farming systems exploiting synergies of horticulture, aquaculture and small livestock rearing to reduce waste and expenses on agricultural inputs; and increase food production diversity. • Promote resilience to climate variability and change of infrastructure essential for the food system (such as storage facilities, roads) and for overall health (such as health care facilities, WASH infrastructure) • Promote renewable energy use (such as biogas and solar); seek alternative energy sources to hydropower that may be unavailable during periods of drought. • Promote strategies that aim at reducing the food sector carbon footprint through sustainable food production, food consumption and waste reduction.
Service delivery	
Management of the environmental determinants of health	• Improve household food production and livelihoods (i.e. diversification of household food production for self-consumption to improve the nutritional quality of the family diet). • Enhance the access and affordability of sustainable and healthy foods. • Enhance coverage of maternal and child health care needs to near universal levels. • Strengthen public health systems and basic clinical care systems including the availability of essential drugs. • Address known environmental risk factors and water-related diseases. • Integrate nutrition and hygiene education in interventions for the treatment of severe malnutrition, diarrhoeal illness and other common childhood illnesses. • Promote good nutrition and hygiene practices, such as breastfeeding, complementary feeding for infants beyond six months of age, improved hygiene practices including hand-washing, and deworming programmes. • Deliver micronutrient supplementation for young children and their mothers (such as periodic vitamin A supplements and therapeutic zinc supplements for diarrhoea management). • Provide micronutrients through food fortification for all (such as salt iodization, iron fortification). • Ensure universal access to clean potable water and improved sanitation. • Promote sustainable land use management and integrated agro-forestry systems to reduce deforestation, restore degraded soils, promote biodiversity within the agricultural system; and sustainable exploitation of nutrient-rich non-wood forest products, in particular in areas with traditional agro-forestry knowledge. • Create a restored, diversified natural resource base and ensure that populations have the capacities and means for sustainable management of their natural resources.

Building block and resilience component	Examples
Climate- informed health and nutrition programmes	• Use school-based approaches (school feeding programmes, school gardens, nutrition education) to include considerations of climate variability and long-term change into existing nutrition initiatives. • Ensure therapeutic feeding for malnourished children with special foods, including prevention or treatment for moderate undernutrition and the treatment of severe undernutrition (severe acute malnutrition) with ready-to-use therapeutic foods (RUTFs) during food crises. • Implement short-term emergency and seasonal safety nets that are gender-sensitive (such as food- and cash-transfer and micro-finance initiatives to increase financial access to foodstuffs). • Provide education on healthy diets and sustainable food systems.
Emergency preparedness and management	• Enhance local capacities to identify and address public health and nutritional risks and emergencies, including adequate training of community health workers and clinical staff in therapeutic and community-based management of severe malnutrition. • Ensure that high-risk regions have access to nutritional and therapeutic commodities including antibiotics and RUTF. • Develop nutrition early warning and early response systems; and improve contingency planning (e.g. prior to the onset of an emergency, most vulnerable populations should be readily identifiable and response protocols should be in place). • Develop community-based management of acute malnutrition, and increase coverage and access to emergency health and nutritional interventions via mobile or community-based therapeutic feeding centres. • Accelerate priority lifesaving health services in high-risk zones, including treatment of medical complications of severe acute malnutrition and interventions to control communicable diseases • Establish "safe corners" for mothers and infants during emergencies. • Develop or strengthen existing insurance programmes for farmers. • Support responsive institutions grounded in the local context. • Enhance local capacities by building on local, indigenous and traditional knowledge with institutions at all levels.
Financing	
Climate, health and nutrition financing	• Mobilize existing and emerging climate funds to support nutrition-focused adaptation actions and target most vulnerable populations, such as women and children in communities most at risk of undernutrition. • Ensure that national adaptation plans include adequate budgetary allocations to address nutrition problems.

Source: Modified by WHO from Climate change and nutrition security. UNSCN; 2010 (http://www.unscn.org/files/Statements/Bdef_NutCC_2311_final.pdf, accessed 29 November 2018).

Additional resources:

Section 8 Resources in Annex 1 includes key resources of international standards for nutrition interventions, and a selection of actions to prepare for acute and chronic malnutrition.

Section 9

Monitoring adaptation progress

Effective monitoring should aim to ensure that: recognized risks to nutrition are being appropriately managed; population vulnerabilities do not worsen; and identified gaps in coverage or increasing vulnerability are countered. Management of climate-related nutritional risks will evolve as climatic environments, economies and populations change, and as more is understood about the relationships between weather/climate and nutrition. Thus, adaptation is a process that is often planned amid uncertainty, with incomplete knowledge, and often requiring substantial learning, capacity-building and institutional change. Monitoring of baselines and adaptation plans plays a critical role in this process. Plans and resources for monitoring should be included in the adaptation plan. To identify needs and inform adjustments in interventions, both: (i) changing risk conditions at short-, medium- and long-term scales, and (ii) the degree of desired impact from policy, programme and/or project outputs adaptation, must be tracked. The variables to be monitored are the same ones included in the baseline and should cover all categories affecting vulnerability (climate hazard exposure, risk factors, existing measures, adaptive capacity and nutritional status). The suite of indicators to be monitored will vary according to the timeframe of likely response, requiring more frequent review of some, and only occasional monitoring of other indicators (see below).

- **Immediate and short term decision-needs** for emergency nutrition planning to respond to drought or flooding, may use metrics similar to World Food Programme Emergency Food Security Assessment,[e] or the Integrated Food Security Phase Classification (IPC) acute malnutrition monitoring indicators *(2)*.[f]
- **Medium term decision-needs** for programmatic modification and strategy re-evaluation to prepare for climate shocks and stresses may want to use metrics similar to the IPC indicators for chronic malnutrition.
- **Long term planning decision-needs** for policy change and investment to address social and food systemwide implications of climate change, may want to use metrics similar to those proposed by FAO[g] and used in "the state of food security and nutrition in the world"[h] and other reports *(89)*.
- All variables should undergo long-term monitoring, and be synchronized where possible with indicators collected through existing national and global scale food security and nutritional monitoring or through early warning systems (such as JMP, IPC, Famine Early Warning System (FEWS), MICS, DHS).

e Emergency food security assessment handbook http://www.wfp.org/content/emergency-food-security-assessment-handbook, accessed 29 November 2018.

f Integrated food security phase classification http://www.ipcinfo.org/ipcinfo-detail-forms/, accessed 29 November 2018.

g FAO Food security indicators: http://www.fao.org/economic/ess/ess-fs/ess-fadata/en/#.Uvs5BEKSx-E, accessed 29 November 2018.

h FAO The state of food security and nutrition in the world: http://www.fao.org/3/I9553EN/i9553en.pdf, accessed 29 November 2018.

Section 10

Conclusions

Managing the health and nutritional risks of climate change involves an iterative management process that starts with:

- assessing the current and likely future vulnerability of the target community or region;
- estimating the extent of future undernutrition burdens due to climate change;
- designing and implementing policies and programmes to reduce current and future food insecurity and undernutrition;
- improving maternal and child care, and feeding practices;
- increasing the climate resilience of health systems;
- minimizing health risks due to climate change; and
- monitoring and evaluating these policies and programmes to identify necessary modifications.

This process should go hand in hand with overall strengthening of the six building blocks of the health system (i.e. leadership and governance, service delivery, health workforce, financing, essential medical products and technologies, and health information systems). Through new technologies research and development and stakeholder advocacy the potential adverse consequences for food and nutrition security can be minimized and/or managed. This work may include changes in agricultural practice (such as development of crops tolerant to different environmental stress), improvements in water management (such as recycling water, encouraging water conservation) and addressing the underlying and basic determinants of malnutrition to improve the four dimensions of food security (i.e. availability, access, stability and utilization).

As food security is necessary, but not a sufficient condition for nutrition security, it is also very important to ensure adequate health services alongside a sanitary environment. Strengthening and increasing the climate resilience of health systems and improving access to health services are fundamental to decreasing overall vulnerability and tackling undernutrition.

Stakeholder engagement is integral to understanding and protecting the nutrition of vulnerable populations. At each step of the V&A, opportunities should be sought to involve all relevant stakeholders in the process and communicate findings to stakeholders, decision-makers, researchers and the public for dialog about local risks and available options to protect community health and nutrition from the threats of climate change.

Coordination of the assessment should ensure consistency and scientific integrity across thematic assessments. This study can be an important complement to existing studies on climate change and agriculture, and fill knowledge gaps about human and social impacts of climate change in your country.

Annex 1. Resources

Resources for Section 3: Climate change and undernutrition

Key reports provide background of current knowledge on linkages of climate change and agriculture, food security and nutrition. UNFCCC National Communication submissions provide climate impact assessments from around the world.

CARE 2011: *Adaptation and food security*. Working brief 2011. https://careclimatechange.org/wp-content/uploads/2015/05/adapt_FNS_brief.pdf, accessed 30 November 2018.

FAO, IFAD, UNICEF, WFP and WHO 2018: *The state of food security and nutrition in the world 2018. Building climate resilience for food security and nutrition*. Rome: FAO; 2018 (http://www.fao.org/3/I9553EN/i9553en.pdf, accessed 14 February 2019).

FAO 2017: *The state of food security and nutrition in the world.* http://www.fao.org/3/a-i7695e.pdf, accessed 30 November 2018.

FAO 2016: *The state of food and agriculture – climate change, agriculture and food security* http://www.fao.org/3/a-i6030e.pdf, accessed 30 November 2018.

FAO 2008: *Climate change and food security: A framework document* http://www.fao.org/forestry/15538–079b31d45081fe9c3dbc6ff34de4807e4.pdf, accessed 30 November 2018.

IPCC Fifth Assessment Report: *Working Group II: impacts, adaptation, and vulnerability* http://ipcc.ch/report/ar5/wg2/, accessed 30 November 2018.

- Chapter 7: Food security and food production systems
- Chapter 11: Human health: impacts, adaptation and co-benefits

Committee on World Food Security: *Food security and climate change* http://www.fao.org/cfs/cfs-hlpe/reports/hlpe-food-security-and-climate-change-report-elaboration-process/en/, accessed 30 November 2018.

2015 Global Nutrition Report: highlights the critical relationship between climate change and nutrition http://www.globalnutritionreport.org/the-report/the-report-2015/, accessed 30 November 2018.

Global Panel on Agriculture and Food Systems for Nutrition: Policy brief – Climate-smart food systems for enhanced nutrition (video) https://www.glopan.org/climate-change, accessed 30 November 2018.

Levy B, Patz J: *Climate change and public health.* 2015; Chapter 8 – Health impacts related to food and nutrition security.

UNFCCC: National Communication submissions from non-annex I partieshttps://unfccc.int/process-and-meetings/transparency-and-reporting/reporting-and-review-under-the-convention/national-communications-and-biennial-update-reports-non-annex-i-parties/national-communication-submissions-from-non-annex-i-parties, accessed 30 November 2018.

UNICEF, WHO, World Bank Group: *Joint child malnutrition estimates* 2017 http://apps.who.int/gho/data/node.wrapper.nutrition-2016**,** accessed 30 November 2018.

UNSCN:

- *Sustainable food systems and health – The convenient truth of addressing climate change while promoting health (2015)* https://www.unscn.org/en/resource-center/UNSCN-Publications?idnews=1427, accessed 30 November 2018.
- *Activities of the UNSCN – Climate change and nutrition (2013)* https://www.unscn.org/en/resource-center/UNSCN-Publications?idnews=1681, accessed 30 November 2018.
- *Climate change: food and nutrition security implications (2010) News 38* http://www.unscn.org/files/Publications/SCN_News/SCN_NEWS_38_03_06_10.pdf, , accessed 30 November 2018.
- Enhancing women's leadership to address the challenges of climate change on nutrition security and health https://www.unscn.org/en/resource-center/UNSCN-Publications, accessed 30 November 2018.

WHO, UNFCCC: *Health and climate country profiles* http://www.who.int/globalchange/resources/country-profiles/en/, accessed 30 November 2018.

WHO 2015: *Human health and climate change in Pacific island countries* http://iris.wpro.who.int/bitstream/handle/10665.1/12399/9789290617303_eng.pdf, accessed 30 November 2018.

World Food Programme: Food insecurity and climate change vulnerability map https://www.metoffice.gov.uk/food-insecurity-index/, accessed 30 November 2018.

Resources for Section 5: Establishing baselines

Includes datasets and indicators useful to construct national and subnational vulnerability baselines.

Food insecurity and nutrition datasets

WHO Nutrition Landscape Information System (NLIS): brings together all existing WHO Global Nutrition Databases, as well as other existing food and nutrition-related data from partner agencies. NLIS is a web-based tool which provides nutrition and nutrition-related health and development data in the form of automated country profiles. (http://www.who.int/nutrition/nlis_interpretationguide_isbn9789241599955/en/index.html, accessed 28 November 2018).

Multiple indicator cluster surveys – Provides national level data on child health, hygiene and nutrition (http://mics.unicef.org/surveys, accessed 28 November 2018).

Demographic and health surveys – National and Subnational scale household survey data, including historical datasets. (http://dhsprogram.com/data/available-datasets.cfm, accessed 28 November 2018).

Nutritional risk factor datasets

FAOSTAT provides time-series and cross sectional data relating to food and agriculture for 200 countries, including Food Balance Sheets of national consumption patterns. ((http://faostat3.fao.org/faostat-gateway/go/to/home/E, accessed 28 November 2018).

Integrated Food Security Phase Classification (IPC) standardized tools that provide "common currency" for classifying the severity and magnitude of food insecurity. Situation analyses, maps, and national profiles of food insecure countries, under regional and country work. (http://www.ipcinfo.org/, accessed 28 November 2018).

IFPRI Global Hunger Index: Comprehensively measures and tracks hunger globally and by country and region. (http://www.ifpri.org/book-8018/ourwork/researcharea/global-hunger-index, accessed 28 November 2018).

DevInfo: database of official UN statistics used in monitoring global progress towards the Millennium Development Goals. Can be used to create tables, graphs and maps of key indicators. (www.devinfo.org, accessed 28 November 2018).

UN Sustainable Development Goals: indicators database – Provides data on SDG indicators (https://unstats.un.org/sdgs/indicators/database/ accessed 28 November 2018).

World Bank. Indicators: Listing of available development indicators (http://data.worldbank.org/indicator, accessed 28 November 2018).

World Bank. Databases: Provides national scale socio-economic development databases, including pre-formatted tables, reports and other resources. http://data.worldbank.org/, accessed 28 November 2018).

WHO estimates of the global burden of foodborne diseases (http://www.who.int/foodsafety/publications/foodborne_disease/fergreport/en/, accessed 28 November 2018).

WHO/UNICEF Joint Monitoring Programme for Water Supply and Sanitation
Data & Estimates: (https://www.wssinfo.org/data-estimates/tables/, accessed 28 November 2018).

Climate change datasets (summarized climate information)

UNFCCC National Communications (Non-Annex I)
Available reports on climate impacts and actions submitted by non-annex 1 countries to the UNFCCC. (http://unfccc.int/national_reports/non-annex_i_natcom/items/2979.php, accessed 28 November 2018).

UNDP Country Climate Change Profiles: Country-level climate data summaries for 61 countries use existing climate data to generate a series of country-level studies of climate observations and the multimodel projections made available through the World Climate Research Programme (WCRP) Coupled Model Intercomparison Project phase 3 (CMIP3). (http://www.geog.ox.ac.uk/research/climate/projects/undp-cp/, accessed 28 November 2018).

World Bank Climate Change Knowledge Portal: Online tool of comprehensive global, regional, and country data related to climate change and development. (http://sdwebx.worldbank.org/climateportal/index.cfm, accessed 28 November 2018).

Capacity and interventions datasets

WHO UNFCCC Climate and Health Country Profile Project: Series of country-specific profiles providing snapshots of the climate hazards and health risks. They present opportunities for health co-benefits though mitigation actions and provide a global platform to track national progress in policy response and implementation (http://who.int/globalchange/resources/countries/en/, accessed 28 November 2018).

Global database on the Implementation of Nutrition Action (GINA) (https://extranet.who.int/nutrition/gina/en, accessed 28 November 2018).

WHO | Essential Nutrition Actions: Annex 3: 16 Country Case Studies: Summarizes efficacy of national nutrition programmes and interventions (http://apps.who.int/iris/bitstream/10665/84409/1/9789241505550_eng.pdf, accessed 28 November 2018).

Guidance on selecting indicators

WHO

Proposed nutrition indicators (2011) – Indicators to monitor the implementation of the comprehensive implementation plan (http://www.who.int/nutrition/EB128_18_backgroundpaper4_nutrition_indicators.pdf, accessed 28 November 2018).

Indicators for the Global Monitoring Framework on Maternal, Infant and Young Child Nutrition – The monitoring framework has a **core set of indicators**, to be reported by all countries and an **extended set of indicators**, from which countries can draw to design national nutrition surveillance systems fitting the specific epidemiological patterns and program decisions. (http://www.who.int/nutrition/topics/proposed_indicators_framework/en/, accessed 28 November 2018).

World Health Assembly resolutions and documents

http://www.who.int/nutrition/topics/wha_nutrition/en/, accessed 28 November 2018).

Food and Nutrition Technical Assistance

Indicators for Assessing Infant and Young Child Feeding Practices: Parts 1, 2, and 3 – Multiyear effort funded by USAID to develop and reach consensus on a set of simple, valid, and reliable indicators. They describe and provide guidance for collection of eight core and seven optional infant and young child feeding (IYCF) http://www.fantaproject.org/monitoring-and-evaluation/iycf-indicators, accessed 28 November 2018).

FAO

Technical manual version 2.0: Evidence and standards for better food security decisions 2012 *(2)* – Common indicators used to measure each phase of food security (p. 32–36) http://www.ipcinfo.org/ipcinfo-detail-forms/ipcinfo-resource-detailo/en/c/162270/, accessed 28 November 2018).

Resources for Section 6: Assessing the sensitivity of nutrition to climate

Includes data sources and relevant information on climate variables to assist with sensitivity analysis.

FAO

Global Information and Early Warning System (GIEWS) – The GIEWS Workstation is a web-based GIS mapping tool for managing national food security and early warning data. http://www.fao.org/giews/en/, accessed 28 November 2018).

Golden Gate Weather Services

El Niño and La Niña Years and Intensities – local influences should be accounted for appropriately in sensitivity analyses. (http://ggweather.com/enso/oni.htm, accessed 28 November 2018).

El Niño				La Niña		
Weak – 10	Moderate – 7	Strong – 5	Very Strong – 3	Weak – 10	Moderate – 4	Strong – 7
1952–53	1951–52	1957–58	1982–83	1954–55	1955–56	1973–74
1953–54	1963–64	1965–66	1997–98	1964–65	1970–71	1975–76
1958–59	1968–69	1972–73	2015–16	1971–72	1995–96	1988–89
1969–70	1986–87	1987–88		1974–75	2011–12	1998–99
1976–77	1994–95	1991–92		1983–84		1999–00
1977–78	2002–03			1984–85		2007–08
1979–80	2009–10			2000–01		2010–11
2004–05				2005–06		
2006–07				2008–09		
2014–15				2016–17		
				2017–18		

Table 10: Sources of national and regional scale climate data

Source	Description	Available at:
World Bank and Columbia University	Historical variability of precipitation and temperature at various time scales (interannual, decadal, and long-term linear trend) over the 20th century near a user-selected location.	http://iridl.ldeo.columbia.edu/maproom/Global/World_Bank/Climate_Variability/index.html, accessed 28 November 2018
Columbia University	Climatologies give the monthly (or seasonal) behaviour in an average year for temperature, precipitation and wind.	http://iridl.ldeo.columbia.edu/, accessed 28 November 2018
	Climate and Health Resource Room	http://iridl.ldeo.columbia.edu/maproom/Health/index.html, accessed 28 November 2018
US – National Oceanic and Atmospheric Administration	Ocean Nino Index: indicates El Nino/La Nina Years	http://www.elnino.noaa.gov/, accessed 28 November 2018 http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/ensostuff/ensoyears.shtml, accessed 28 November 2018
	Climate Prediction Center	http://www.cpc.ncep.noaa.gov/, accessed 28 November 2018
World Meteorological Organization	World Climate Applications and Services Programme	http://www.wmo.int/pages/prog/wcp/wcasp/wcasp_home_en.html, accessed 28 November 2018
West and Central Africa	Regional Climate Center	http://www.acmad.net/new/, accessed 28 November 2018
East Africa/ Horn	Regional Climate Center	http://www.icpac.net/, accessed 28 November 2018

Resources for Section 7: Anticipating future risks and impacts

Includes notable existing projections of climate change impacts on food security and nutrition; as well as projections of population growth and other relevant variables useful for creating climate-based projections of food security and malnutrition.

Short term prediction resources

Humanitarian Early Warning System (http://www.eldis.org/organisation/A7288, accessed 29 November 2018).

Famine Early Warning System: Central America and Caribbean, Central Asia, East and Southern, and West Africa, and West (http://www.fews.net/, accessed 28 November 2018).

Climate Prediction Center (http://www.cpc.ncep.noaa.gov/products/international/index.shtml, accessed 28 November 2018).

El Nino monitoring and predictions (http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/enso_advisory/ensodisc.shtml, accessed 28 November 2018).

Strengthening surveillance of and response to foodborne diseases (http://www.who.int/foodsafety/publications/foodborne_disease/surveillancemanual/en/, accessed 28 November 2018).

Long term prediction resources

Table 11. Existing futures studies of food security and malnutrition, associated with climate

Resource	Projections	Available at:
Climate change, crop yields and undernutrition: development of a model to quantify the impact of climate scenarios on child undernutrition *(28)*	Monte Carlo simulation using current national food availability and undernutrition data to parameterize and validate a global model, based on estimations of relationship between a lack of food and stunting	https://www.ncbi.nlm.nih.gov/pubmed/21844000, accessed 28 November 2018
Food security, farming, and climate change to 2050 *(84)*	Global scale projection of agricultural commodity supply, demand, trade, prices Regional scale projection of malnutrition in children (as a function of food availability)	http://www.ifpri.org/publication/food-security-farming-and-climate-change-2050, accessed 28 November 2018
International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT) model IMPACT Water Simulation Model	Global food supply, demand, trade, prices and food security Global scale interactions between water supply and demand and food supply, demand, and trade	http://www.ifpri.org/book-751/ourwork/program/impact-model, accessed 28 November 2018 http://impact-model.ifpri.org/, accessed 28 November 2018
IPCC Fifth Assessment Report: Food security and food production systems	Global scale projection of crop yields Regional scale projection of hunger	http://ipcc.ch/report/ar5/wg2/, accessed 28 November 2018
Climate change and human health: Spatial modelling of water availability, malnutrition, and livelihoods in Mali, Africa *(90)*	Water availability, malnutrition, livelihoods in Mali	http://www.sciencedirect.com/science/article/pii/S0143622811001627, accessed 28 November 2018

Resource	Projections	Available at:
World agriculture towards 2030/2050: the 2012 revision *(91)*	FAO Futures Study, inclusive of climate scenarios. Regional scale.	http://www.fao.org/fileadmin/templates/esa/Global_persepctives/world_ag_2030_50_2012_rev.pdf, accessed 28 November 2018
Looking ahead to 2050: scenarios of alternative investment approaches *(92)*	Study of global and regional agricultural futures, accounting for economics, water and climate scenarios	http://www.iwmi.cgiar.org/assessment/Water%20for%20Food%20Water%20for%20Life/Chapters/Chapter%203%20Scenarios.pdf, accessed 28 November 2018
Shaping the future of global food systems: a scenarios analysis *(93)*	This report, copublished by the World Economic Forum and Deloitte, presents four scenarios for the future of global food systems	https://www.weforum.org/whitepapers/shaping-the-future-of-global-food-systems-a-scenarios-analysis, accessed 28 November 2018
Global and regional health effects of future food production under climate change: a modelling study *(85)*	Study that estimated "excess mortality attributable to agriculturally mediated changes in dietary and weight-related risk factors by cause of death for 155 world regions in the year 2050"	https://www.ncbi.nlm.nih.gov/pubmed/26947322, accessed 28 November 2018

Other food security futures studies

French National Institute for Agricultural Research (INRA) – French Agricultural Research Centre for International Development CIRAD 2009. Agrimonde – Scenarios and challenges for feeding the world in 2050: Creates scenarios of food resources and their uses for 2050, quantified at regional scale. (http://www.cirad.fr/en/news/all-news-items/articles/2009/science/results-of-the-agrimonde-foresight-study, accessed 27 November 2018)

United Nations Environment Programme (UNEP), International Assessment of Agricultural Science and Technology for Development (IAASTD) – Rosegrant MW, Fernandez M, Sinha A. Looking into the future for agriculture and AKST. In: Agriculture at a crossroads (McIntyre BD, Herren HR, Wakhungu J, Watson RT, eds), pp. 307–376 Washington, DC: Island Press; 2009.

Multistakeholder, multidisciplinary international process (2005–2007) includes, thematic overviews and summary for regional decision makers on food security futures. (http://www.fao.org/fileadmin/templates/est/Investment/Agriculture_at_a_Crossroads_Global_Report_IAASTD.pdf, accessed 27 November 2018).

UNEP: GEO-6: Global Environment Outlook: All regional assessments.
The Global Environment Outlook gives a global and regional overview of the environmental factors contributing to human health and well-being.
(https://europa.eu/capacity4dev/unep/blog/geo-6-global-environment-outlook-all-regional-assessments, accessed 27 November 2018).

Table 12. Datasets and tools for creating climate-based projections of food security and malnutrition

Source	Description	Available at:
IPCC	IPCC Data Distribution Centre provides climate, socioeconomic and environmental data, both from past and future scenarios	http://www.ipcc-data.org/, accessed 28 November 2018
IPCC (Fifth Assessment Report)	Regional climate scenario maps	http://ipcc.ch/report/ar5/wg1/, accessed 28 November 2018
WHO	Estimates and projections of expected disease burdens for 2015 and 2030	http://www.who.int/healthinfo/global_burden_disease/projections/en/index.html, accessed 28 November 2018
United Nations Population Fund	National-level demographic projections to 2050 for all countries	http://www.un.org/popin/wdtrends.htm, accessed 28 November 2018
Climate: Analysis, Monitoring and Forecasts	Historical, current and future climate conditions around the globe	http://iridl.ldeo.columbia.edu/maproom/Global/index.html, accessed 28 November 2018
FAO Modelling System for the Agricultural Impacts of Climate Change	Statistical downscaling method for processing general circulation model output data; a hydrological model for estimating water resources for irrigation; a crop growth model to simulate future crop yields; and effect of changing yields on national economies	http://www.fao.org/climatechange/mosaicc/en/, accessed 28 November 2018
Climate and Agriculture Map Room Columbia University	Maps and analyses of seasonal statistics of historical temperature and precipitation, seasonal temperature and precipitation forecasts, and general circulation model skill maps for regions of Asia and South America, map of African farming systems	http://iridl.ldeo.columbia.edu/maproom/Agriculture/index.html, accessed 28 November 2018
Decision Support System for Agrotechnology Transfer	Modelling programme comprises crop simulation models for 28 common crops in 100+ countries	http://dssat.net/, accessed 28 November 2018
UK Met Office Hadley Centre for Climate Science and Services	PRECIS (Providing Regional Climates for Impacts Studies) generates high-resolution climate change information and can be applied to any world region	http://www.metoffice.gov.uk/services/climate-services/international/precis, accessed 28 November 2018 http://www.metoffice.gov.uk/research/applied/international-development/precis, accessed 28 November 2018
WCRP Group on Regional Climate (WGRC)	CORDEX global coordination of regional climate downscaling for improved regional climate change adaptation and impact assessment	https://www.cordex.org, accessed 28 November 2018
FAO	Data management and mapping tools and systems for food security	http://www.ipcinfo.org/fileadmin/user_upload/eufao-fsi4dm/docs/Data%20Management%20and%20Mapping%20Tools%20and%20Systems%20for%20Food%20Security.pdf, accessed 28 November 2018

Resources for Section 8: Identifying adaptation options

Includes key resources of international standards for nutrition interventions, and a selection of actions to prepare for acute and chronic malnutrition.

Choosing adaptation options

WHO

Operational framework for building climate resilient health systems. 2015 (http://apps.who.int/iris/bitstream/10665/189951/1/9789241565073_eng.pdf, accessed 27 November 2018).

WHO guidance to protect health from climate change through health adaptation planning. 2014 (http://apps.who.int/iris/bitstream/10665/137383/1/9789241508001_eng.pdf, accessed 27 November 2018).

Gender, climate change, and health. 2014
(http://www.who.int/globalchange/publications/reports/gender_climate_change/en/, accessed 27 November 2018).

UN System Standing Committee on Nutrition

Climate change and nutrition security. 2010
(http://www.unscn.org/files/Statements/Bdef_NutCC_2311_final.pdf, accessed 27 November 2018).

European Climate Adaptation Platform

PROVIA – Programme of Research on Climate Change Vulnerability, Impacts and Adaptation (http://climate-adapt.eea.europa.eu/metadata/organisations/provia-programme-of-research-on-climate-change-vulnerability-impacts-and-adaptation, accessed 27 November 2018).

International Institute for Sustainable Development

Climate resilience and food security: A framework for planning and monitoring. 2013 (http://www.iisd.org/pdf/2013/adaptation_CREFSCA.pdf, accessed 27 November 2018).

Action Contre la Faim (ACF) International

Enhancing climate resilience and food & nutrition security. ACF approach to face climate change, hunger and undernutrition in at-risk communities. 2012

(http://www.preventionweb.net/files/34143_34093acf2012.enhancingclimateresili.pdf, accessed 27 November 2018).

Nutrition specific interventions

WHO

Essential nutrition actions: improving maternal, newborn, infant and young child health and nutrition. 2013 (http://apps.who.int/iris/bitstream/10665/84409/1/9789241505550_eng.pdf, accessed 27 November 2018).

Global Strategy for Infant and Young Child Feeding (http://www.who.int/nutrition/topics/global_strategy/en/, accessed 27 November 2018).

Nutrition in emergencies list of publications (http://www.who.int/nutrition/publications/emergencies/en/index.html, accessed 27 November 2018).

WHO, UNICEF, World Food Programme, UN System Standing Committee on Nutrition. Joint statement on the community-based management of severe acute malnutrition. (http://www.who.int/maternal_child_adolescent/documents/a91065/en/index.html, accessed 27 November 2018).

Nutrition sensitive interventions:

Agriculture

FAO

Managing climate risk using climate-smart agriculture. 2016 (http://www.fao.org/3/a-i5402e.pdf, accessed 27 November 2018).

Community Finance

IFPRI

Case study on the International Food Policy Research Institute (IFPRI) and conditional cash transfer (CCT) and non-conditional cash transfer (NCCT) program; 2009 (https://www.ifpri.org/publication/case-study-international-food-policy-research-institute-ifpri-and-conditional-cash, accessed 27 November 2018).

Leveraging social protection programs for improved nutrition: summary of evidence prepared for the Global Forum on Nutrition-Sensitive Social Protection Programs, 2015 (http://www.ifpri.org/publication/leveraging-social-protection-programs-improved-nutrition, accessed 27 November 2018).

Lancet

Willett W, Rockström J, Loken B, Springmann M, Lang T, Vermeulen S, et al. Food in the Anthropocene: the EAT – Lancet Commission on healthy diets from sustainable food systems. Lancet 2019: 393 (10170): 447–92).

EAT-Lancet Commission Summary Report. [website] (https://eatforum.org/eat-lancet-commission/eat-lancet-commission-summary-report/, accessed 14 February 2019).

Annex 2. Glossary

Anthropometry is the use of human body measurements to obtain information about nutritional status.

Anthropometric indices are combinations of human body measurements and their comparison to reference data. For example, measurements of weight and height may be combined to produce body mass index (weight/ height2 (see definition below)); or weight may be related to height, through the use of reference data that have been developed/adopted by WHO.

Body mass index (BMI) is an index of weight-for-height commonly used to classify underweight, overweight and obesity in adults. It is defined as the weight in kilograms divided by the square of the height in metres (kg/m2).

A **Climate-sensitive disease** is a disease that is sensitive to weather and climate factors, with the current spatial distribution and seasonal transmission being affected.

Chronic food insecurity is a long-term or persistent inability to meet minimum food requirements.

Coping strategies are activities to which people resort in order to obtain food, income and/or services when their normal means of livelihood has been disrupted or other shocks/hazards decrease their access to basic needs.

Complementary feeding refers to transition from breastfeeding to family foods and generally covers the period from six to 18–24 months of age.

Crude mortality rate is the "mortality rate from all causes for a population". It is measured by the formula: (number of deaths during a specific time period) / (number of persons at risk of dying during that period) x (time period) (World Food Programme and Centers for Disease Control and Prevention 2005). The under-five mortality rate is calculated the same way; however, the reference thresholds differ from crude mortality rate.

DALY – Disability Adjusted Life Year. One DALY is considered one lost year of "healthy" life. The sum of these DALYs across the population, or the burden of disease, can be thought of as a measurement of the gap between current health status and an ideal health situation where the entire population lives to an advanced age, free of disease and disability (WHO).

Dietary quality is the extent to which the diet is optimal in delivering essential nutrients, including types and forms of nutrients. This comprises dietary adequacy of vitamins, minerals, energy and protein, and also specific forms of fats, carbohydrates and proteins. Both quantity and nutrient density are important determinants of dietary quality. Nutrient requirements are based on a number of criteria, depending on the specific nutrient. In addition to nutrients, fibre is a necessary component of a healthy diet.

Drought is a temporary reduction in water or moisture availability significantly below the normal or expected amount (norm) for a specified period. The key assumptions of such a definition are that:

- reduction is temporary (if the reduction were permanent, then terms such as "dry" and "arid"
- are more appropriate)

- reduction is significant
- reduction is defined in relation to a "norm", i.e. normal expectation
- the period taken as the basis for the norm is specified (United Nations Disaster Management Training Programme. Drought and famine).

Early warning system refers to information collection, analysis and use aimed at predicting, preventing and mitigating the effects of future hazards and risks (Famine Early Warning System Network).

Environmental enteropathy (also called **tropical enteropathy**) is a subclinical condition caused by constant fecal–oral contamination, resulting in blunting of intestinal villi and intestinal inflammation. It contributes to poor response to nutritional therapy *(94)*.

Famine is the absolute inaccessibility of food to an entire population or subgroup of a population, potentially causing death in the short term (Action contre la Faim).

Fetal-growth restriction or intrauterine growth restriction (IUGR) is a condition whereby a fetus does not grow at the normal rate within the womb. This may be caused by maternal malnutrition and is an important contributor to stunting and wasting. Studies indicate that as much as 20% of childhood stunting may originate in fetal growth conditions and it increases the odds of child mortality across Africa, Asia and Latin America *(5)*.

Food consumption is the amount of food consumed by individuals, households, communities and nations. Indicators capture the amount of foods consumed in a population, often using indirect markers associated with food availability. Food consumption per person is the amount of food, in terms of quantity, of each commodity and its derived products for each individual in the total population. The dietary energy consumption per person is the amount of food, in kcal per day, for each individual in the total population (FAO).

Food safety includes all measures and principles to assure that food that reaches the consumer is safe and does not cause foodborne diseases (WHO).

Food system encompasses: (i) activities related to the production, processing, distribution, preparation and consumption of food; and (ii) the outcomes of these activities contributing to food security (food availability, with elements related to production, distribution and exchange; food access, with elements related to affordability, allocation and preference; and food use, with elements related to nutritional value, social value and food safety). The outcomes also contribute to environmental and other securities (such as income). Interactions between and within biogeophysical and human environments influence both the activities and the outcomes (Global Environmental Change and Food Systems online).

Food security exists when all people, at all times, have physical and economic access to sufficient, nutritious and safe food that meets their dietary needs and food preferences for an active and healthy life. Measurement of food security is most frequently based upon the absence of food insecurity. Food security is built on four pillars:

i. Food availability: sufficient quantities of food available on a consistent basis.

ii. Food access: having sufficient economic and physical resources to obtain appropriate foods for a nutritious diet.

iii. Food use: appropriate use based on knowledge of basic nutrition and care, as well as adequate water and sanitation.

iv. Stability over time: exposure to short-term risks that endanger long-term progress (food prices, climate).

Food insecurity is a situation that exists when people lack secure access to sufficient amounts of nutritious and safe food for normal growth and development, and an active and healthy life. It may be caused by the unavailability of food, insufficient purchasing power, inappropriate distribution or inadequate use of food at the household level. Food insecurity may be chronic, seasonal or transitory.

- Chronic food insecurity – long-term or persistent inability to meet minimum food consumption requirements.
- Transitory food insecurity – short-term or temporary inability to meet minimum food consumption requirements, indicating a capacity to recover. As a rule of thumb, short periods of food insecurity related to sporadic crises can be considered transitory.
- Cyclical food insecurity – habitual, most often seasonal, variations in food security. As a rule of thumb, if seasonal food insecurity is present for at least six months in a year, it can be considered chronic; if it lasts for less than six months a year, it can be considered transitory (FAO).

Hazard is the potential occurrence of a natural or human-induced physical event or trend that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems and environmental resources *(95)*.

Hunger used in this report is synonymous with chronic undernourishment.

Low-birth-weight babies are those born weighing less than 2500 grams (5 pounds, 8 ounces). These newborns are especially vulnerable to illness and death during the first months of life.

Macronutrients are generally considered as proteins, carbohydrates and fats that are available to be used for energy. These are measured in grams.

Malnutrition refers to all forms of poor nutrition caused by a complex array of factors including dietary inadequacy (deficiencies, excesses or imbalances in energy, protein and micronutrients), and encompasses both undernutrition and overnutrition.

Micronutrients are vitamins, minerals and certain other substances that are required by the body in small amounts. These are measured in milligrams or micrograms. Deficiencies result in "hidden hunger" and is a consequence of both chronic and acute malnutrition. These can coexist with other forms of malnutrition, such as underweight, stunting and wasting as well as overweight and obesity *(96)*.

Morbidity rate is the number of newly appearing cases of a disease/condition per unit of time divided by the population at risk. Prevalence also may be used to estimate the burden of morbidity and is defined as the number of individuals with an illness/condition divided by the total population at one point in time (point prevalence) or during a period of time (period prevalence) (WHO).

Mortality rate is a measure of the number of deaths (in general, or due to a specific cause) in a given population over the total population per unit time (WHO).

Nutrition refers to the appropriate intake of nutritionally adequate food in relation to the body's dietary needs.

Nutrition security is a situation that exists when secure access to an appropriately nutritious diet is coupled with a sanitary environment as well as adequate health services and care, to ensure a healthy

and active life for all household members. Nutrition security differs from food security in that it also considers the aspects of adequate caring practices, health and hygiene in addition to dietary adequacy.

Nutrition-sensitive interventions are designed to address the underlying determinants of nutrition (which include poverty, education, household food security, care for mothers and children, primary health care services and sanitation) but not necessarily having nutrition as the predominant goal. See listing of key nutrition sensitive interventions at https://extranet.who.int/nutrition/gina/en/node/8894 (accessed 27 November 2018).

Nutrition-specific interventions are interventions or programmes that address the immediate determinants of nutrition and development in target populations, i.e. adequate food and nutrient intake, feeding, caregiving and parenting practices, and low burden of infectious diseases. See listing of key nutrition specific interventions at https://extranet.who.int/nutrition/gina/en/node/8893, (accessed 27 November 2018).

Nutritional status is the physiological state of an individual that results from the relationship between nutrient intake and requirements, and from the body's ability to digest, absorb and use these nutrients.

Ready-to-use therapeutic foods (RUTFs) are high energy, fortified, ready-to-eat foods suitable for the treatment of children with severe acute malnutrition.

Severe acute malnutrition is defined as the percentage of children aged 6 to 59 months whose weight for height is below minus three standard deviations from the median of the WHO Child Growth Standards, or by a mid-upper-arm circumference less than 115 mm, with or without nutritional oedema.

Shocks are sudden events with negative impacts on nutrition status and/or food security. They can be natural or caused by human action (World Food Programme. Food Security Assessment Learning Repository).

Stunting is an irreversible outcome of chronic nutritional deficiency during the first thousand days of a child's life, and affects one quarter of children under five years of age. Stunted children are significantly shorter than they could have been with proper nutrition (i.e. low height for age), and often have weaker immune systems that make them more vulnerable to disease, and other causes of mortality. Brain development is impaired which translates to a loss of two to three years of learning *(97,98)*. Some evidence shows that when people stunted in childhood enter the workforce, their diminished physical and cognitive development can reduce their earning capacity by as much as 22% *(99)*. The cause of stunting, chronic malnutrition, is affected by the local environmental and economic and social conditions which can result in a perpetual cycle of malnutrition.

Undernourishment is a measurement of hunger and food deprivation, and refers to the proportion of the population whose dietary energy consumption (measured in kilocalories per capita per day) is less than a predetermined threshold. This threshold is country specific and is measured in terms of the number of kilocalories required to stay in good health while performing light physical activity. It is a conservative indicator that does not take into account the extra needs of people performing extraneous physical activity, nor seasonal variations in food consumption or other sources of variability such as inter-individual differences in energy requirements.

Undernutrition is the outcome of undernourishment, and/or poor absorption and/or poor biological use of nutrients consumed as a result of repeated infectious disease. It includes being underweight for

one's age, too short for one's age (stunted), dangerously thin for one's height (wasted) and deficient in vitamins and minerals (micronutrient malnutrition).

Underweight, also known as **growth retardation**, is a composite form of undernutrition that includes elements of stunting and wasting. It is defined as the percentage of children aged 0 to 59 months whose weight for age is below minus two standard deviations (moderate and severe underweight) and minus three standard deviations (severe underweight) from the median of the WHO Child Growth Standards.

Vulnerability is the susceptibility to harm, which can be defined in terms of a population or a location. Vulnerability to climate change is the degree to which a system is susceptible to, or unable to cope with, the adverse effects of climate variability and change. Vulnerability is dynamic and may itself be influenced by climate change (such as extreme weather events affecting health infrastructure). From a health perspective, vulnerability can be defined as the summation of all risk and protective factors that ultimately determine whether a subpopulation or region experiences adverse health outcomes due to climate change *(100)*. Characteristics of a region, such as baseline climate, abundance of natural resources (such as access to fresh water), elevation, infrastructure and other factors can alter vulnerability.

Wasting, indicates acute malnutrition often triggered by crises situations, seasonal food shortages or disease. Wasted children weigh much less than the average child at their height (i.e. low weight for height). Research indicates that severely wasted children are 6.3 times more likely to die of diarrhoea than children with good nutritional status *(4)*. This is because malnutrition increases the risk of contracting and dying from illnesses such as malaria, diarrhoea, cholera, measles and pneumonia *(12)*.

Z score (or standard deviation score) in anthropometric assessment is the deviation of the value for an individual from the median value of the reference population, divided by the standard deviation for the reference population (UNICEF).

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PUBLIC HEALTH AND ENVIRONMENT

A vulnerability and adaptation (V&A) assessment is a vital first step in adapting to climate change. This technical guide on V&A assessment for undernutrition and climate change is part of a series of World Health Organization (WHO) guidance aiming to inform the management of priority climate-sensitive health impacts to climate change.

The series aims to: (i) to help clarify the relationships and casual links that exist between climate change and priority health outcomes; and (ii) to offer specific direction and resources for assessing these associations and designing adaptation options for protecting health in a changing climate. This guide provides information specific to a thematic analysis of undernutrition and climate change, and should be used in conjunction with the general WHO guidance on conducting health vulnerability and adaptation assessments *"Protecting health from climate change: vulnerability and adaptation assessment"* (available from: http://www.who.int/entity/globalchange/publications/Final_Climate_Change.pdf)

This guide presents a basis for understanding how nutrition, specifically undernutrition, is currently influenced by climate and weather, and may be further exacerbated by climate change. It provides guidance on how to: (i) identify populations and regions vulnerable to undernutrition and the reasons for their vulnerability; (ii) establish relevant baselines that can be analysed and monitored; (iii) conduct analyses to project how undernutrition may be impacted in the future due to climate change; and (iv) identify appropriate responses to mitigate and monitor these risks over time.

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