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Chapter Two

Issues in Food Security

2.1 Food Security Concepts and Definitions

In May 2007, at the 33rd Session of the Committee on World Food Security, FAO issued a statement to reaffirm its vision of a food-secure world:

"*FAO's vision of a world without hunger is one in which most people are able, by themselves, to obtain the food they need for an active and healthy life, and where social safety nets ensure that those who lack resources still get enough to eat."* (FAO, 2007f)

This vision has its roots in the definition of food security adopted at the World Food Summit (WFS) in November 1996: "Food security exists when all people at all times have physical or economic access to sufficient safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life" (FAO, 1996).

In the year and a half following WFS, the Inter-Agency Working Group that established the Food Insecurity and Vulnerability Information and Mapping System (FIVIMS) elaborated a conceptual framework that gave operational meaning to this definition (Figure 1). FAO reaffirmed this view in its first published assessment of the implications of climate change for food security, contained in its 2015 to 2030 projections for world agriculture.

FAO stressed that "food security depends more on socio-economic conditions than on agroclimatic ones, and on access to food rather than the production or physical availability of food". It stated that, to evaluate the potential impacts of climate change on food security, "it is not enough to assess the impacts on domestic production in food-insecure countries. One also needs to (i) assess climate change impacts on foreign exchange earnings; (ii) determine the ability of food- surplus countries to increase their commercial exports or food aid; and (iii) analyse how the incomes of the poor will be affected by climate change" (FAO, 2003b: 365 366).

Food and Nutrition Security: Concepts and Definitions

Food security is commonly defined as the physical, social and economic ability to access sufficient, safe and nutritious food. The four pillars of food security that are intrinsic to this definition are availability of food, stability of the food supply, access to adequate food and utilization of food (Table 1). While not always explicit, each pillar contains nutrition considerations and components crucial to the links in the chain between national food economies, households and individual well-being.

Undernourishment may be considered "an extreme form of food insecurity", defined as the state "when caloric intake is below the minimum dietary energy requirement". Hunger, on the other hand, may be described as "the uneasy or painful sensation caused by a lack of food... the recurrent and involuntary lack of access to food". "Hidden hunger" is the term used to refer to micronutrient deficiencies which affect around 2 billion people worldwide.

The term nutrition security is sometimes used interchangeably with food insecurity, but in fact the definition is much broader. Food security is necessary, but not sufficient for nutrition security. Nutrition security considers care, health, and hygiene practices in addition to food security. The Food and Agriculture Organization (FAO) defines nutrition security as "A situation that exists when secure access to an appropriately nutritious diet is coupled with a sanitary environment, adequate health services and care, in order to ensure a healthy and active life for all household members".

It has been proposed that the two terms should be brought together as "food and nutrition security" to better reflect the importance of nutrition's role in sustainable food security and make the explicit distinction between quantity (energy) and quality (dietary diversity) at the individual level. In this regard, the conceptual framework proposed by the Food Insecurity and Vulnerability Information and Mapping System (FIVIMS) provides a useful guide for intervention points for inter-sectoral nutrition activities to address food insecurity. FIVIMS is an inter-agency initiative, with FAO acting as a Secretariat, set up to monitor progress in achieving the World Food Summit goal for eradicating hunger and achieving food security. Similar to the

UNICEF conceptual framework for causes of malnutrition10,11 in women and children, the FIVIMS model includes health and care components but includes all population sectors, with specific emphasis on the role of the food economy. The FIVIMS framework promotes food and agriculture based strategies to increase access to and consumption of adequately diversified diets. However, it also takes cognisance of the fact that improved availability, stability and access to food at aggregate levels does not necessarily imply improved energy and nutrient intake at individual levels. The inter- connectedness between links in the chain are clearly demonstrated by this framework.

2.2 Climate and Climate Change Concepts and Definitions

Climate and Its Measurement

Climate refers to the characteristic conditions of the earth's lower surface atmosphere at a specific location; weather refers to the day-to-day fluctuations in these conditions at the same location. The variables that are commonly used by meteorologists to measure daily weather phenomena are air temperature, precipitation (e.g., rain, sleet, snow and hail), atmospheric pressure and humidity, wind, and sunshine and cloud cover.

When these weather phenomena are measured systematically at a specific location over several years, a record of observations is accumulated from which averages, ranges, maximums and minimums for each variable can be computed, along with the frequency and duration of more extreme events.

Climate can be described at different scales. Global climate is the average temperature of the earth's surface and the atmosphere in contact with it, and is measured by analysing thousands of temperature records collected from stations all over the world, both on land and at sea. Most current projections of climate change refer to global climate, but climate can also be described at other scales, based on records for weather variables collected from stations in the zones concerned. Zonal climates include the following:

- ***Latitudinal climates*** are temperature regimes determined by the location north or south of the equator. They include polar climate, temperate climate, sub-tropical climate and

tropical climate.

- ***Regional climates*** are patterns of weather that affect a significant geographical area and that can be identified by special features that distinguish them from other climate patterns. The main factors determining regional climate are: (i) differences in temperature caused by distance from the equator and seasonal changes in the angle of the sun's rays as the earth rotates; (ii) planetary distribution of land and sea masses; and (iii) the worldwide system of winds, called the general circulation, which arises as a result of temperature difference between the equator and the poles. Examples of regional climates are maritime climate, continental climate, monsoon climate, Mediterranean climate, Sahelian climate and desert climate.

- ***Local climates*** have influence over very small geographical areas, of only a few kilometres or tens of kilometres across. They include land and sea breezes, the orographic lifting of air masses and formation of clouds on the windward side of mountains, and the heat island effects of cities. Under certain conditions, local climatic effects may predominate over the more general pattern of regional or latitudinal climate. If the area involved is very small, such as in a flower bed or a shady grove, it may be referred to as a microclimate. Microclimates can also be created artificially, as in hothouses, museum displays or storage environments where temperature and humidity are controlled.

The Climate System

The climate system is highly complex. Under the influence of the sun's radiation, it determines the earth's climate (WMO, 1992) and consists of:

- the atmosphere: gaseous matter above the earth's surface;
- the hydrosphere: liquid water on or below the earth's surface;
- the cryosphere: snow and ice on or below the earth's surface;
- the lithosphere: earth's land surface (e.g., rock, soil and sediment);
- the biosphere: earth's plants and animal life, including humans.

Climate Variability and Climate change

There is no internationally agreed definition of the term **"climate change"**. Climate change can refer to: (i) long-term changes in average weather conditions (WMO usage); (ii) all changes in the climate system, including the drivers of change, the changes themselves and their effects (GCOS usage); or (iii) only human-induced changes in the climate system (UNFCCC usage).

There is also no agreement on how to define the term "**climate variability**". Climate has been in a constant state of change throughout the earth's 4.5 billion-year history, but most of these changes occur on astronomical or geological time scales, and are too slow to be observed on a human scale. Natural climate variation on these scales is sometimes referred to as "climate variability", as distinct from human-induced climate change. UNFCCC has adopted this usage (e.g., UNFCCC, 1992). For meteorologists and climatologists, however, climate variability refers only to the year-to-year variations of atmospheric conditions around a mean state (WMO, 1992).

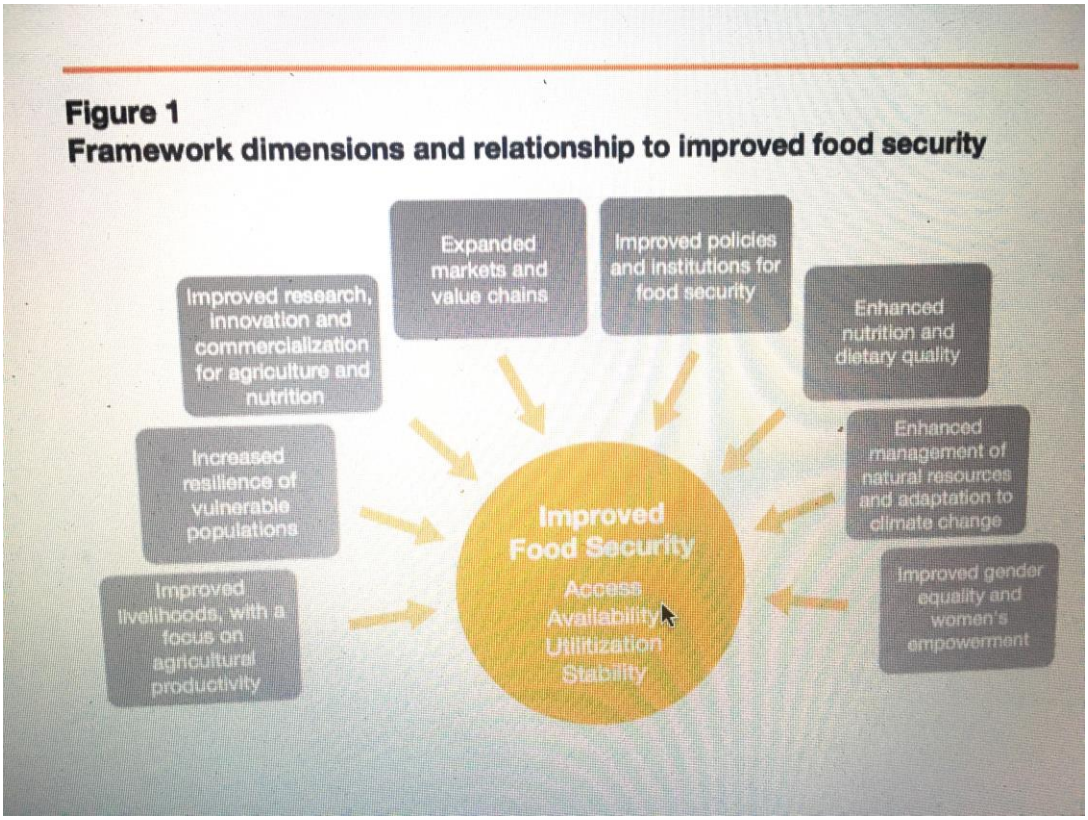
To assess climate change and food security, FAO prefers to use a comprehensive definition of climate change that encompasses changes in long-term averages for all the essential climate variables. For many of these variables, however, the observational record is too short to clarify whether recent changes represent true shifts in long-term means (climate change), or are simply anomalies around a stable mean (climate variability).

2.3 Theoretical Framework for Understanding Food Security

An effective, shared framework requires that partners share a common understanding of the overall meaning of food security and have agreement, to some extent, on the causal pathways that lead to food security. Using a definition of food security promoted by FAO, the Framework assumes the following definition: "*Food security [is] a situation that exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life*."2 This definition promotes four key elements of food security: Access, Availability, Utilization and Stability. These elements cut across all areas of food security programming and undergird the theories of change that work towards improved food security. At the highest levels, the partnership recognizes that our most important goal is to reduce poverty and hunger.

Dimensions of the Theoretical Framework

1. Improved livelihoods, with a focus on agricultural productivity
2. Increased resilience of vulnerable populations
3. Improved research, innovation and commercialization for agriculture and nutrition
4. Expanded markets and value chains
5. Improved policies and institutions for food security
6. Enhanced nutrition and dietary quality
7. Enhanced management of natural resources and adaptation to climate change
8. Improved gender equality and women's empowerment



In addition to these primary dimensions, there are a number of cross-cutting themes which were considered in the formulation of the evidence gaps or questions under each dimension, including:

1. Inclusive agricultural growth

2. Social, economic and environmental sustainability 3. Employment generation

4. Local capacity-building

5. Empowerment and equality

In the following sections, the eight FSLF dimensions are described in better detail, paying special attention to the causal pathways towards improved food security and any areas or causal linkages for which there is a paucity of evidence.

Dimension 1: Improved livelihoods, with a focus on agricultural productivity

This dimension aims to contribute evidence and learning about how best to design and implement investments to support food availability and/or access to food. There are existing studies that demonstrate that improved agricultural productivity and intensification can impact greater physical availability of food and greater economic and physical access to food, which is necessary for food security. Evidence also shows that agricultural sector growth can be an effective and direct pathway to promote inclusive economic growth and alleviate poverty and hunger. Other studies have shown that increases in agricultural productivity contribute proportionately more to economic development and can have up to six times greater impact on the poor than industrial growth.3 It has been shown that in resource-poor, low-income countries outside of sub-Saharan Africa, agricultural growth is five times more poverty reducing than growth in non-agricultural sectors. Within sub-Saharan Africa, poverty reduction is 11 times greater through agricultural growth than non-agricultural growth.4 Clearly, there is growing evidence that provides development partners and partner countries confidence in the causal pathway represented through an agricultural growth and improved nutrition-driven approach.

The Global Donor Platform for Rural Development notes that 75 per cent of farms in Africa and Asia measure two hectares or less. Small farms are home to two thirds of the three billion people living in rural areas of developing countries, and 75 per cent of the rural population is poor. Low agricultural productivity persists among this population, which results in low levels of farm and rural household income and low levels of consumption in these countries. These lend themselves to poor nutrition behaviours due to low availability and low ability to access diverse sources of

quality nutritious foods. Additionally, poor farmer organization and inefficient market access and infrastructure inhibit small farmers and increases pressure on them to liquidate their new and improved production, exacerbating the problem. Development partners and host country partners are also confident that low levels of productivity are a key constraint to improved livelihoods. There are a number of reasons for this, including existing disincentives that impede adoption of improved practices and application of technology to improve agricultural productivity, lack of proper or weak institutions (land tenure and property rights, extension services) and market failures such as access to finance and poor market infrastructure. Therefore, it is important under this theme to identify the critical gaps in information and answer questions regarding the most effective and efficient approaches to overcome key constraints to agricultural productivity.

Critical gaps

1. What are the main disincentives to adoption of more productive technologies, inputs and practices among small farmers? What can we learn from targeted meta-studies and South-South learning related to what works and what does not work in promoting increased productivity for smallholder farmers?
2. What are the main disincentives to adoption of employable skills for employment in agricultural value chains among landless/assetless and indigenous populations, women, children and the urban poor?
3. What strategies and approaches are the most effective, efficient and sustainable vehicles for promoting adoption of innovation (credit, risk, information, experience with cultivation, lack of markets, technology, practices, behaviours) and diffusion of products and new technologies among poor people, women and the socially marginalized?
4. What are the critical pathways to productivity increases for smallholder farmers across the value chain? To what extent do agricultural productivity interventions in the staple and non-staple crop value chains lead to the generation or improvement of on-farm income and consumption, and off-farm employment?
5. What are the critical institutional factors influencing the promotion of agricultural productivity among smallholders, including contemporary land issues in Latin America,

sub-Saharan Africa and South Asia that influence rural livelihoods?

6. What are the most effective approaches for social safety net programmes that link with, and that lead to, increased agricultural productivity?

Dimension 2: Increased resilience of vulnerable populations

Increased resilience of vulnerable communities and populations cuts across many of the other dimensions identified in this Framework because resilience to shocks at the household, community and national levels is itself a multidimensional phenomenon. For this Framework, disaster resilience is defined as: "the ability of countries, communities and households to manage change, by maintaining or transforming living standards in the face of shocks or stresses – such as earthquakes, drought or violent conflict – without compromising their long-term prospects."5 The work done by FAO and WFP to develop a resilience measurement tool provides a useful starting point for thinking about these dimensions, which include income and food access, assets such as land and livestock, social safety nets (formal and informal), basic services (health, nutrition, education), adaptive capacity and the stability of these factors over time. A better understanding of how these related, but distinct and at times conflicting aspects of resilience influence and interact with one another is critical for designing effective programmes and measuring results.

Since resilience is multidimensional, increasing resilience requires improving the capacity of households, communities and countries to absorb, cope with, adapt to and manage shocks through various combinations of the pathways outlined above. Shocks can be simple or complex, transitory or chronic. Promoting resilience against different types of shocks (or better yet a typology of shocks) remains an area of critical importance, both for the humanitarian transformation framework and development in general.

Value chain investments in markets with lower risk and lower entry barriers that encourage the participation of poorer rural households and seek to expand their economic opportunities, provide a prominent example of increasing resilience through improved income and food access. However, these investments also highlight an inherent tension between efforts to increase productivity on the one hand and efforts to mitigate risk on the other. Investments in risk

mitigation, such as index-based insurance (crop or livestock) and productive safety nets that allow poorer and food-insecure households to assume greater risk, hold promise in this regard but are largely untested. Analysis of the impacts of these and other efforts to increase resilience through investments that increase productivity whilst also mitigating risk, will contribute significantly to an improved understanding of how best to achieve inclusive agriculture-led growth.

Critical gaps

1. What interventions have improved the ability of vulnerable households to withstand (i.e. maintain stable consumption and protect assets) and/or recover (i.e. regain consumption levels and rebuild lost assets) from common and extreme shocks affecting their economic activities? In what ways?
2. Which agricultural productivity interventions have had the greatest impact on resilience of households and individuals to recover from or withstand common and extreme shocks?
3. To what extent do different interventions to promote market access (such as promoting access to markets with lower risks and lower entry barriers) lead to the participation of poorer households? What interventions on both the 'push' (social protection) and 'pull' (value chain deepening) sides improve the participation of poor people in value chain activities?
4. Have safety net programmes promoted greater participation of poorer households in prudent risk taking and more remunerative economic activities?
5. What are the most effective economic growth strategies for making poor and vulnerable communities and households more resilient to shocks? How may we best combine investments and programmes to optimize impacts on resilience?

Dimension 3: Improved research, innovation and commercialization for agriculture and nutrition

Agricultural research has consistently been shown to be critical to sustaining and enhancing agricultural productivity growth, which is strongly linked to economic growth and poverty

reduction. In addition to the linkages among agricultural productivity, agriculture-led economic development and poverty reduction, there are multiple interacting direct and indirect pathways through which agricultural research can contribute to improved nutrition. Such issues have been the subject of substantial agricultural research in the social sciences, which provide insight into the role of gender, household coping strategies and resilience as they affect well-being in general and nutrition in particular.

The potentially large and widespread impact of agricultural research occupies a central role in the agricultural development strategies of many development partners. Many ex-post evaluations provide evidence that research programmes and initiatives have been a major contributor in reducing world food prices and increasing real incomes. Greater food availability and access, generated through research innovations, have led to increased caloric and protein intake, especially among poor people, lowering the incidence of hunger, poverty and malnutrition.6 However, large and numerous gaps remain around the types and magnitudes of impacts that can be generated from distinct research activities. Reviews of ex-post impact analyses indicate an overall high rate of return on investments in agricultural research but results vary across regions, over time within regions (e.g. greater gains have been shown in Africa in recent years) and among different types of research. In many settings, constraints at the system level (e.g. access to input and output markets, infrastructure and other factors) may reduce the effectiveness of research-based innovations. Hence, research needs to be done in ways that create, build and maintain information flows between researchers and the user community, which can help clarify research objectives and inform research design and validation.

Many unanswered questions remain around innovations that are most effective at increasing agricultural productivity while mitigating any potential negative impacts on the resource base, or that instead enhance it through increased soil organic matter, water holding capacity or fertility. On the other side of those questions lies the need to acknowledge the economic and development trade-offs between pursuing sustainable intensification versus pursuing unharnessed agricultural production. Evidence gaps also persist around innovations related to biofortification and methods of effectively scaling up proven innovations. Social science research remains a vital contributor to agricultural outcomes that foster both biophysical sustainability and economic and cultural

viability of innovations. It provides learning and understanding of strategies and methods that enhance dissemination and adoption of improved technologies, policies or resource management practices, as well as of the best approaches for improving the effectiveness of agricultural institutions in supporting and sustaining agricultural productivity.

Critical gaps

1. What partnership mechanisms are most cost-effective and sustainable for carrying out high-quality agricultural research?
2. How do public-private partnerships contribute to reducing the cost of research for agriculture and nutrition?
3. How do public-private partnerships add value to research by facilitating innovation, and do they enhance the impact of research on smallholders and other marginalized groups?
4. What innovations to improve agricultural productivity most effectively increase nutritional outcomes?
5. What mechanisms for promoting the adoption or commercialization of new innovations (technology, practices and behaviours) have proven to be cost-effective and sustainable?
6. What are the most effective methods for scaling up proven innovations? What are the best methods for overcoming the constraints that are preventing farmers from adopting and adapting research and development (R&D) outputs more widely?

Dimension 4: Expanded markets and value chains

Meeting the goal of reduced poverty and hunger requires learning how to create inclusive value chains that are market-led by reaching further down the wealth continuum to involve resource-poor farmers in the uptake of new technologies and market opportunities. Once this first challenge is solved, a second challenge will be to create a cargo net or other graduation pathway that will allow the poorest households to build the minimum assets needed to participate in inclusive value chains. While the minimum asset threshold for effective participation in value chain programmes is far from clear, it is apparent that the adoption of new technologies by small farms, participation in local and regional markets and participation in value chains is stunted by

low knowledge, risk and uncertainty. It is also clear that their participation in high-value chains is affected by lack of post-harvest technology, access to storage and know-how related to quality standards, phytosanitary norms and certification.

Recent work on agricultural value chains and the role of the private sector in Thailand8 highlights that food is increasingly channeled via formal sector outlets and there is a natural tendency towards concentration at all levels in the value chain. Entrepreneurs seek to shorten and rationalize the supply chains, private sector managed value chains shift to higher value products and the private sector develops its own standards for food quality and safety. These private sector actions often lead to a 'professionalization' of farming, accompanied by increased farm size, often in a contract farming context, which results in new and different challenges for smallholder farmers.

Private sector companies tend to source from larger farms and avoid smallholders in 'scale-dualistic contexts'.9 However, there are instances of private companies sourcing from smallholders, usually in contexts where the agrarian structure is dominated by small farmers. When they do so, they source from smallholders with the requisite non-land assets (such as irrigation, paved roads, green houses, farm equipment and farmers' associations). When smallholders are included in modern value chains, they benefit in terms of incomes and assets; this generates positive externalities in the local labour markets (increased labour use and hired labour, on- and off-farm). These benefits result from:

• Higher productivity
• Higher farm gate prices, for higher value and higher quality products, especially when graded and supplied in a consistent manner • Implicit input and credit subsidies
• Lower market risks

Sourcing from smallholders needs to be facilitated by a better understanding of the 'midstream' (wholesale segment) in order to assess how downstream restructuring affects the upstream actors (smallholders). As initial farm-sector structure and government policy affect the pace and nature of the agrofood industry transformation, and as this influences the inclusion of smallholders in value chains, there is a significant role for governments to create an enabling policy environment

and to provide assets for small farmers to ‘make the grade’ and to participate in transforming the food economy.

Critical gaps

1. What output market-based incentives exist for the adoption of innovations/ interventions designed to increase agricultural productivity?
2. What types of investments (farm to retail) in value chain development deliver outcomes and result in poverty reduction, and with what level of effectiveness and efficiency?10
3. What has been the impact of market-related infrastructure interventions (transport, services, etc.) on smallholder farming transformation? What is the impact when infrastructure investments are used in combination with more traditional value chain or productivity-enhancing interventions?
4. Which commercial arrangements ensure that interventions in agricultural value chain development effectively and efficiently lead to the development of local institutions that enable smallholders to participate and/or that produce systemic behaviour change; and how?
5. Are farmers’ organizations and collective enterprises effective in helping to build the incomes and assets of their member households? Which factors have led to market power within the value chain and the ability to determine fair and efficient market prices?
6. Which mechanisms/investments are most effective and efficient in reducing post-harvest losses?
7. Which mechanisms enhance net income/value addition for smallholder farmers?
8. Have structured demand interventions (such as P4P) stimulated agricultural and market development for low-income smallholder farmers? What are the characteristics of specific structured demand interventions that have maximized agricultural market development for low-income farmers? Which areas of the smallholder value chains can benefit from pull mechanisms?
9. What impact do quality, safety and environmental standards, both public and private,

have on smallholder farmer participation in high-value chains? Which mechanisms are most effective and efficient in assisting farmers to meet standards?

Dimension 5: Improved policies and institutions for food security

There is no lack of expertise and analysis among international organizations, developing country governments, donor agencies, partner governments, NGOs, the private sector and civil society, on the causal pathways of food insecurity and food security. An academic or technical understanding of the problem, however, is not sufficient. The agricultural sector and the rural economy are complex and contested spaces. There are many actors – public, private and civil society – large and small – formal and informal. All of these actors have important roles in the development process, despite having unique interests, many of which are in conflict and competition.

Public policy and resource allocation in agriculture have direct economic consequences – advantages and disadvantages – for the individuals, households and firms, who are the drivers of agricultural development. They often compete for access to economic assets and opportunity, advocate for public policy frameworks that facilitate their own interests and seek advantage over their competitors in the marketplace. Policymaking in agriculture is difficult and although laws, regulations and expenditures are all made, the processes through which decisions are made are frequently unclear, ill-defined and, as a consequence, are often non-inclusive, inequitable and inefficient.

The negative effects of the uneven influence of significant stakeholder groups (that seek their interests without consideration of impacts on society as a whole) on public policies and institutions in the agricultural sector indicate weak institutions and demonstrate that more evidence is needed on the specific institutional arrangements that will lead to effective policymaking and delivery in the sector. In each country, the challenge lies in building a shared consensus on the appropriate institutional architecture (i.e. the rules and frameworks that govern how policies are made, who participates in the policy process and how). Moreover, the challenge entails identifying and implementing policies that will create an enabling environment for poverty reduction and food security. In the process, it will be necessary to address and resolve

contentious issues (such as access to public resources and services, control over productive assets, regulation and market failure) and the nature of the institutions that govern the agricultural sector will often determine a society's ability to resolve such difficult issues.

Improved policies and institutions are required in most development contexts to build a more enabling environment for agricultural growth, increased trade and more equitable and sustainable economic growth. The targeted outcomes and causal pathways of institutional and policy reform are diverse and complex varying across geographic regions, but most seek to create a better, more efficient, inclusive, transparent policy process at various governance levels (e.g. country, region, globe). This in turn will create a better policy environment for development interventions and private-sector activities to be more effective in improving food security. Thus, enhancing the quality of institutional architecture is of paramount importance to create and sustain a policy environment that is conducive to food security. However, knowledge of the appropriate institutional architecture for improved food security under different social, political and economic settings (e.g. stage of development) is limited.

In some countries, improving institutional architecture for food security has entailed increased and inclusive participation in the policy process, while in other countries, increased food security has resulted when policy processes constituted fewer participants and less inclusiveness. Thus, research on the key features of different institutions in different contexts is needed to help illuminate what constitutes improved quality in institutional architecture, policymaking and policies that would then create an overall enabling environment for food security. This improved enabling environment would in turn help increase and sustain incentives, opportunities and security for smallholder farmers and businesses. Together, these accelerate or deepen outcomes related to agricultural productivity, market access, public and private investment, employment and resilience that ultimately lead to inclusive agricultural growth, food security and poverty reduction.

Building an institutional architecture for improved policy formulation entails several components that could include the enhancement of capacity (in and outside of government) for improved policy work at the country, regional and global levels, promoting inclusive participation of multiple partners and stakeholders, designing and instituting mechanisms for transparency and

accountability, and creating structures and space for science to generate and provide a relevant evidence base for policy formulation. It may also entail improving communication, information flow across the various stakeholders, the quality of data, and monitoring and evaluation systems, which are all vital for transparency and accountability. Also, potentially important are steps to ensure open feedback and peer-review among the scientific community, policy makers, as well as citizens, to ensure demand-driven policy processes and outcomes. These processes will likely produce sustainable policy improvements that accelerate countrywide, regional and global reductions in poverty and improvements in food security. Impacts of the architecture will be:

- Policies that directly accelerate progress towards the goals of poverty reduction and food security
- Policies that indirectly accelerate progress by complementing public and development partner investments in agriculture, and that function to make those investments more cost-effective
- A more stable and transparent policy environment that often is a prerequisite for greater engagement of private sector and smallholder agricultural investments

Critical gaps

1. What are the most effective approaches to promote policymaking processes that are inclusive of all major stakeholders?

2. What are the most effective approaches to promote evidence-based policymaking processes (i.e. generation, provision and use of evidence)?

3. What has proven to be the most effective package of institutional and policy reforms to increase agricultural productivity and prepare for effective agricultural transformation (i.e. to equip small farmers with viable skills and employment options outside of agriculture)?

4. What are the most effective set of policy reforms to attract responsible private-sector investment into smallholder agriculture and enable private-sector activities to improve food security?

5. What policies and policymaking processes have promoted the integration of the agriculture and nutrition sectors?
6. Which aspects of land tenure and property rights have been most effective in improving land security and investments in smallholder agriculture?
7. Which policies most effectively promote adaptation to climate change and strengthen resilience?

Dimension 6: Enhanced nutrition and dietary quality

Many interventions that propose to improve nutrition and diet quality are typically nutrition-specific interventions that address the immediate causes of undernutrition (such as energy and specific nutrient insufficiency) but they do not address its underlying causes. Similarly, agriculture-focused interventions typically aim to improve agricultural productivity, income and access to markets for poor people, but by failing to make the link to nutritional outcomes they may be missing a unique opportunity to improve nutrition and diet quality.

When health and agricultural interventions are implemented in tandem, there are several pathways by which agricultural interventions can impact nutrition:

- Food production for own consumption
- Increased income from sale of agricultural commodities and greater farm productivity
- Women's empowerment to make decisions on food production and provision at the household level
- Lower food prices resulting from increases in food supply
- Macroeconomic effects of agricultural growth
- Improved intake of essential nutrients through the introduction of nutritionally enhanced crops

- Improved population health can also increase agricultural productivity

  (a virtuous cycle), but agriculture is also associated with health risks from zoonotic diseases and sources of contamination in the food chain

Critical gaps

1. Which technologies, products and approaches result in improved diets and nutritional outcomes, and are demonstrated to be cost-effective and sustainable (i.e. technologies and approaches that improve yields, incomes, dietary diversity and consumption, and that reduce sources of contamination in the food chain)?
2. How is the impact of these different technologies, products and approaches mediated by social and economic factors, whether income group, gender or social category, as well as within the household?
3. What combination of nutrition-specific interventions and behaviour change strategies are most cost-effective and sustainable?
4. What are the impacts of food and agricultural policy change on nutrition through the value chain, including on diet-related non-communicable diseases? How do different pathways to agricultural transformation and smallholder commercialization impact upon diets and nutritional outcomes?
5. What governance structures facilitate the promotion of effective nutrition- sensitive agricultural development and lead to improved nutritional outcomes at global, national and community levels?

Dimension 7: Enhanced management of natural resources and adaptation to climate change

Poor rural people face a series of interconnected natural resource management challenges. They are on the front line of climate change impacts; the ecosystem and biodiversity on which they rely are increasingly degraded. Some of these challenges include:

- Access to suitable agricultural and is declining in both quantity and quality

- Forest resources are increasingly restricted and degraded
- Crops are produced on typically marginal rain-fed land, with increased water scarcity
- Energy and agricultural input prices are on a rising long-term trend
- Declining fish and marine resources threaten essential sources of income and nutrition

  At the same time, agriculture, food production and distribution are important contributors to climate change. Farmers are not only victims but also contributors to climate change. Evidence on the balance between these two tendencies needs to be sharpened.

There are a range of issues related to the management of natural resources and climate change adaptation for which evidence is scarce. Food security programming can greatly benefit from increased understanding around:

- Improved land management and climate-resilient agricultural practices and technologies: landscape management, conservation agriculture strategies, ecosystem services, the importance of governance (both incentives and governance systems), land tenure and responsible agricultural investment
- Increased availability of and access to water, and efficiency of waterusefor smallholder agricultural production and processing
- Increased human capacity of adaptation and weather-related disaster risk reduction at the local level
- Documented and disseminated knowledge of climate-smart smallholder agriculture

As in other dimensions of the Framework, challenges in conducting evaluations can impede learning around resource management and climate change adaptation. The application of rigorous impact evaluation techniques to assess the effectiveness of climate change interventions has so far been limited. In particular, the longer development timeline needed to generate and measure long-term impacts in this area make conducting evaluations more complicated.

Critical gaps

1. What interventions improve the ability of vulnerable households to withstand and/or recover from extreme climate shocks that affect their economic activities?
2. What are the best incentives to encourage governments to adopt and implement proper legislation and to manage natural resources sustainably? What are the best incentives to encourage community-level management and maintenance of natural resources and climate-resilient infrastructure?
3. How can climate change adaptation programmes facilitate equitable sharing of benefits among heterogeneous groups with varying land/water use priorities?
4. What are the impacts of land tenure and land tenure security on sustainable natural resources management?
5. What are the most effective incentives to promote the implementation of binding and non-binding international/national instruments governing natural resource management?
6. What are the most effective natural resource management technologies/ techniques to reduce natural resource degradation (e.g. soil management techniques to reduce soil loss and land degradation, water management/ irrigation techniques to reduce water loss and improve efficiency)?
7. Are climate-smart agricultural practices and approaches reflected in national planning processes? Does this translate into improved and sustainable natural resource management on the ground?

Dimension 8: Improved gender equality and women's empowerment

Gender equality and the empowerment of women are critical goals on the road to food security. Equality and empowerment are viewed as an objective, in and of themselves, representing a better quality of life for those who are empowered and greater social stability for communities experiencing equality. At the same time, equality and empowerment are often considered

important intermediate objectives for development partners targeting economic growth and poverty reduction.

Impact evaluations of programmes would ideally show how these programmes affect gender equality and women's empowerment, but also how improved gender equality and women's empowerment precipitate poverty reduction, hunger alleviation and malnutrition.

Critical gaps

1. Have agricultural productivity interventions reduced gender gaps in access to and use of production inputs? What are the pathways?
2. How have agriculture and nutrition projects or approaches effectively improved gender equality and women's empowerment, specifically in terms of agricultural production, decision-making over and access to credit, control over income, leadership in the community and time use?
3. Does gender integration in the implementation of agriculture and nutrition programmes lead to improved food security?
4. Have capacity-building and increased leadership/management opportunities for women led to increased participation of women in leadership roles in the community? Has increased participation of women in leadership roles led to more sustainable resource use and efficient use of community assets?
5. Have interventions advancing commercialization in value chains affected access to paid employment or types of employment for women and men? Have they led to increases or decreases in unpaid work for men or women?
6. Are programmes that emphasize gender equality and women's empowerment more effective at reducing poverty and improving food security?

2.4 Theoretical Framework for Understanding Climate Change

Sociological Analyses of the Causes of Global Climate Change

Sociological research on global climate change has its roots in environmental sociology—a

specialty eld that developed in reaction to increased social awareness of environmental problems in the 1970s. Environmental sociologists examine and theorize the complex and multi-faceted relationship between human beings and their natural environments, including the question: why do social systems tend to exceed their ecological carrying capacities? Beginning in its early days, environmental sociology focused on the social and political dynamics of the environmental movement, studying how people organized around, reacted to, and adapted to air and water pollution, the impacts of technology, controversies over land use, and questions of environmental justice. By the 1980s, environmental sociology expanded its eld of inquiry beyond environmentalism as a social and political movement and began examining the underlying organizational, economic, cultural, and emotional factors that have shaped modern industrial society's relationship to the bio-physical world, in particular the implications for the environment of various models of economic development, political contestation, pre-existing structures of inequality, and questions of sustainability

Environmental sociology has drawn theoretical insights from the broader discipline of sociology in a number of areas, including research on social movements, political sociology, organizational sociology, small group and large-scale decision making, micro and macro foundations of social inequality, community studies, network theory, population and migration research, and models of globalization. Environmental sociologists have reached outside sociology's disciplinary boundaries to borrow and adapt theoretical models from population ecology, geography, and demography, among others. ese di erent conceptual lenses have provided depth and breadth to a number of critical debates among environmental sociologists about the most important and promising theoretical and research questions and about the place of environmental sociology within the discipline of sociology and the social sciences.

e research areas listed below represent some of the major theoretical and methodological strategies used by sociologists to better understand the relationship between humans and their natural world and to identify the ecologically-relevant features of modern industrial nations and their impact on global climate change. Each section contains both a summary of sociological analyses of the social causes of global climate change and promising areas for investigation and questions for future research.

Political Economy: One of sociology's most signi cant contributions to climate change research arises out of attention to the intersecting political and economic orders, at both global and national levels, as contributors and potential mitigators of global climate change. Like all social scienti c approaches, political economy research acknowledges

that climate change is not merely rooted in planetary physical systems, often the main focus of natural scientists, politicians, and the general public. Building on social theories like Allan Schnaiberg's "Treadmill of Production," John Bellamy Foster's "Metabolic Rift," and Marina Fischer-Kowalski's "Social Metabolism," political economy analyses link carbon emissions and their e ect on the global climate to economic and social organization in modern industrial societies. Global political economy research underscores the relationship among national economies, political organizations, resource extraction regimes, and population demographics and their CO2 (carbon dioxide) emissions.

Political economy quantitative approaches examine cross-national data on national CO2 emissions. ey highlight di erences among agrarian, lesser developed, and highly developed countries' metabolic pro les based on per capita consumption of materials and energy output. ey also examine the implications of urbanization, industrialization, and the spread of consumer culture around the world. Environmental sociologists have examined the patterns and drivers of economic growth as they a ect the environment, including cross-national research on the resource use, social metabolic levels, and environmental impacts of industrial and industrializing economies. ey have evaluated hypotheses arising out of ecological modernization and world system models. e role of multi-national corporations in producing and responding to climate change (sometimes simply by "greenwashing" their products) has been well documented by environmental sociologists. Recent trends and areas for new global political economic research re ect a qualitative shift toward understanding the assumptions about progress, notions of individual rights, the ethos of consumption, and de nitions of quality of life in modern industrialized societies.

Human Ecology and Environmental Impact Models: Sociologists have applied theories from ecology to study the complex relationship between humans and their natural environment. e human ecology perspective underscores the socio-spatial dynamics of climate change and varied

interactions humans have with their physical environments across spatial and temporal scales. Drawing on work in geography and urban studies, sociologists have applied this "place-based approach" to research on migration, resource competition, and disaster relief. is perspective provides evidence that while climate change is a global threat, its e ects are experienced locally, and can better be understood when sociologists include data from humans' biophysical environments.13 A major contribution by environmental sociology is modeling the social causes and consequences of environmental change. ese modeling techniques are directly applicable to the study of global climate change. For example, data collected by researchers in the STIRPAT14 research program link CO2 emissions to "...the scale of population, levels of consumption, the pace of material ows, [and] the position of nations in the world system...." Environmental impact researchers have documented many of the pathways and obstacles to transitioning to a low carbon economy on both micro and macro levels. Areas for future research include assessments of carbon trading schemes and the impact of economic development on environmental change in the twenty- rst century global system.

***Strati cation and Status-Attainment E ects on Production and Consumption*:** Sociologists have examined the social factors that drive excessive production and consumption leading to high-throughput, high-waste economies. ese studies investigate the social dynamics of conspicuous consumption and status display coupled with the power of advertising to drive consumers to expand their consumption habits often without regard to either environmental consequences or personal nancial cost. Less well-studied is the role of advertising and public relations rms in shaping and framing public perceptions of global climate change as a scientifically credible or pressing social, economic, and political concern.

Cultural and Meaning Systems: Environmental sociologists use quantitative and qualitative methods to explore the social and cultural processes that shape attitudes, discourses, and ideological dimensions of climate change in public debates and policy processes. is scholarship is relevant to sociological understandings of the causes of climate change in that it explores how publics de ne climate change as a problem or not and view solutions to climate change as necessary and acceptable or not. Of particular importance here is the degree of public acceptance of natural science evidence as a guide to policy formation. Research on cultural and meaning

systems assesses the attitudes, people,
and organizations like the media, public relations rms, and political think tanks that shape public knowledge and opinions about global climate change, examines the social organization and rationales used by activists to promote and challenge scienti c claims, and documents how these groups exert their in uence to shape national agendas. Emerging work in this area asks, what are the social and psychological factors that cause individuals to internalize, react to, or deny the realities of global climate change? Strengthening research capacity to study these issues will be essential in programs designed to mitigate and adapt to climate change

***Policy Process Research*:** Sociologists have employed multi-level analyses to study the range of factors that shape climate policy formation, implementation, and e ectiveness within and across states and countries. is research examines the links between causes of and solutions to climate change; local, national, and international policies governing greenhouse gas production; the role of local, national, and international policies in allowing greenhouse
gas production to escalate, stabilize, or decrease; cross-national comparisons of the social factors that a ect political processes associated with climate change attitudes and policies; the e ect of di erent institutions (i.e., pluralist versus corporatist), interest groups, advocacy coalitions, and participatory venues on the policy process. Important areas of research also include studying the interactions between states and non-governmental/intergovernmental organizations, evaluating the e ectiveness of speci c government policies on decreasing CO2 emissions, and analyzing social and cultural factors that in uence the general public's attitudes about climate change.

Social Organization of Science and Science Policy: Sociological research on the role of partisan politics, shiftsin public discourse, and the in uence of discourse and debates about scienti c ndings in the United States and abroad illustrates the need for projects designed to analyze the social organization of science and science policy. is research gets at the heart of the relationship between the science of climate change and its translation into public understanding and policy formation. Research on the social organization of climate change science and climate policy includes projects that identify features that make climate science and policy distinct from or similar to other science policy debates and implementation issues, explore the role of experts in governments and non-governmental organizations, and investigate the place of climate policy in

changing individual and collective behaviors, attitudes, and beliefs about science and climate change. An important set of research questions are: What are the social processes by which the issue of global climate change emerged and evolved in public discourse? How have these public discussions a ected climate policy? How do policy responses to global climate change work when analyzed in conjunction with the sociology of denial? How do the processes associated with climate public opinion and science policy compare across communities, geographic locales, or countries in the global system? How have di erent sectors within different countries reacted to the IPCC reports on climate change science?

2.5 Climate Change and Food Security

Agriculture, Climate and Food Security

Agriculture is important for food security in two ways: it produces the food people eat; and (perhaps even more important) it provides the primary source of livelihood for 36 percent of the world's total workforce. In the heavily populated countries of Asia and the Pacific, this share ranges from 40 to 50 percent, and in sub-Saharan Africa, two-thirds of the working population still make their living from agriculture (ILO, 2007). If agricultural production in the low-income developing countries of Asia and Africa is adversely affected by climate change, the livelihoods of large numbers of the rural poor will be put at risk and their vulnerability to food insecurity increased.

Agriculture, forestry and fisheries are all sensitive to climate. Their production processes are therefore likely to be affected by climate change. In general, impacts are expected to be positive in temperate regions and negative in tropical ones, but there is still uncertainly about how projected changes will play out at the local level, and potential impacts may be altered by the adoption of risk management measures and adaptation strategies that strengthen preparedness and resilience.

The food security implications of changes in agricultural production patterns and performance are of two kinds:

- Impacts on the production of food will affect food supply at the global and local levels. Globally, higher yields in temperate regions could offset lower yields in tropical regions.

However, in many low-income countries with limited financial capacity to trade and high dependence on their own production to cover food requirements, it may not be possible to offset declines in local supply without increasing reliance on food aid.

- Impacts on all forms of agricultural production will affect livelihoods and access to food. Producer groups that are less able to deal with climate change, such as the rural poor in developing countries, risk having their safety and welfare compromised.

Other food system processes, such as food processing, distribution, acquisition, preparation and consumption, are as important for food security as food and agricultural production are. Technological advances and the development of long-distance marketing chains that move produce and packaged foods throughout the world at high speed and relatively low cost have made overall food system performance far less dependent on climate than it was 200 years ago.

However, as the frequency and intensity of severe weather increase, there is a growing risk of storm damage to transport and distribution infrastructure, with consequent disruption of food supply chains. The rising cost of energy and the need to reduce fossil fuel usage along the food chain have led to a new calculus – "food miles", which should be kept as low as possible to reduce emissions. These factors could result in more local responsibility for food security, which needs to be considered in the formulation of adaptation strategies for people who are currently vulnerable or who could become so within the foreseeable future.

Vulnerability to Climate Change

Uncertainty and risk: Risk exists when there is uncertainty about the future outcomes of ongoing processes or about the occurrence of future events. The more certain an outcome is, the less risk there is, because certainty allows informed choices and preparation to deal with the impacts of hazardous processes or events.

Global climate change projections have a solid scientific basis, and there is growing certainty that extreme weather events are going to increase in frequency and intensity. This makes it highly likely that asset losses attributable to weather-related disasters will increase. Whether these losses involve productive assets, personal possessions or even loss of life, the livelihoods and food security status of millions of people in disaster-prone areas will be adversely affected.

Food system vulnerability: *Overview:* A food system is vulnerable when one or more of the four components of food security – food availability, food accessibility, food utilization and food system stability is uncertain and insecure.

Food availability is determined by the physical quantities of food that are produced, stored, processed, distributed and exchanged. FAO calculates national food balance sheets that include all these elements. Food availability is the net amount remaining after production, stocks and imports have been summed and exports deducted for each item included in the food balance sheet. Adequacy is assessed through comparison of availability with the estimated consumption requirement for each food item.

This approach takes into account the importance of international trade and domestic production in assuring that a country's food supply is sufficient. The same approach can also be used to determine the adequacy of a household's food supply, with domestic markets playing the balancing role.

High market prices for food are usually a reflection of inadequate availability; persistently high prices force poor people to reduce consumption below the minimum required for a healthy and active life, and may lead to food riots and social unrest. Growing scarcities of water, land and fuel are likely to put increasing pressure on food prices, even without climate change. Where these scarcities are compounded by the results of climate change, the introduction of mitigation practices that create land-use competition and the attribution of market value to environmental services to mitigate climate change, they have the potential to cause significant changes in relative prices for different food items, and an overall increase in the cost of an average food basket for the consumer, with accompanying increases in price volatility.

Food accessibility **i**s a measure of the ability to secure entitlements, which are defined as the set of resources (including legal, political, economic and social) that an individual requires to obtain access to food (A. Sen, 1989, cited in FAO, 2003a). Until the 1970s, food security was linked mainly to national food production and global trade (Devereux and Maxwell, 2001), but since then the concept has expanded to include households' and individuals' access to food.

The mere presence of an adequate supply does not ensure that a person can obtain and consume

food – that person must first have access to the food through his/her entitlements. The enjoyment of entitlements that determine people's access to food depends on allocation mechanisms, affordability, and cultural and personal preferences for particular food products. Increased risk exposure resulting from climate change will reduce people's access to entitlements and undermine their food security.

Food utilization refers to the use of food and how a person is able to secure essential nutrients from the food consumed. It encompasses the nutritional value of the diet, including its composition and methods of preparation; the social values of foods, which dictate what kinds of food should be served and eaten at different times of the year and on different occasions; and the quality and safety of the food supply, which can cause loss of nutrients in the food and the spread of food-borne diseases if not of a sufficient standard. Climatic conditions are likely to bring both negative and positive changes in dietary patterns and new challenges for food safety, which may affect nutritional status in various ways.

Food system stability is determined by the temporal availability of, and access to, food. In long-distance food chains, storage, processing, distribution and marketing processes contain in-built mechanisms that have protected the global food system from instability in recent times. However, if projected increases in weather variability materialize, they are likely to lead to increases in the frequency and magnitude of food emergencies for which neither the global food system nor affected local food systems are adequately prepared.

Potential impacts of climate change on food availability: *Production* of food and other agricultural commodities may keep pace with aggregate demand, but there are likely to be significant changes in local cropping patterns and farming practices. There has been a lot of research on the impacts that climate change might have on agricultural production, particularly cultivated crops. Some 50 percent of total crop production comes from forest and mountain ecosystems, including all tree crops, while crops cultivated on open, arable flat land account for only 13 percent of annual global crop production. Production from both rainfed and irrigated agriculture in dryland ecosystems accounts for approximately 25 percent, and rice produced in coastal ecosystems for about 12 percent (Millennium Ecosystem Assessment, 2005).

The evaluation of climate change impacts on agricultural production, food supply and agriculture-based livelihoods must take into account the characteristics of the agro-ecosystem where particular climate-induced changes in biochemical processes are occurring, in order to determine the extent to which such changes will be positive, negative or neutral in their effects.

The so-called "greenhouse fertilization effect" will produce local beneficial effects where higher levels of atmospheric CO2 stimulate plant growth. This is expected to occur primarily in temperate zones, with yields expected to increase by 10 to 25 percent for crops with a lower rate of photosynthetic efficiency (C3 crops), and by 0 to 10 percent for those with a higher rate of photosynthetic efficiency (C4 crops), assuming that CO2 levels in the atmosphere reach 550 parts per million (IPCC, 2007c); these effects are not likely to influence projections of world food supply, however (Tubiello *et al.*, 2007). Mature forests are also not expected to be affected, although the growth of young tree stands will be enhanced (Norby *et al.*, 2005).

The impacts of mean temperature increase will be experienced differently, depending on location (Leff, Ramankutty and Foley, 2004). For example, moderate warming (increases of 1 to 3 oC in mean temperature) is expected to benefit crop and pasture yields in temperate regions, while in tropical and seasonally dry regions, it is likely to have negative impacts, particularly for cereal crops. Warming of more than 3 oC is expected to have negative affects on production in all regions (IPCC, 2007c). The supply of meat and other livestock products will be influenced by crop production trends, as feed crops account for roughly 25 percent of the world's cropland.

For climate variables such as rainfall, soil moisture, temperature and radiation, crops have thresholds beyond which growth and yield are compromised (Porter and Semenov, 2005). For example, cereals and fruit tree yields can be damaged by a few days of temperatures above or below a certain threshold (Wheeler *et al.*, 2000). In the European heat wave of 2003, when temperatures were 6 oC above long-term means, crop yields dropped significantly, such as by 36 percent for maize in Italy, and by 25 percent for fruit and 30 percent for forage in France (IPCC, 2007c). Increased intensity and frequency of storms, altered hydrological cycles, and precipitation variance also have long-term implications on the viability of current world agro-ecosystems and future food availability.

Potential impacts of climate change on food access: *Allocation*: Food is allocated through markets and non-market distribution mechanisms. Factors that determine whether people will have access to sufficient food through markets are considered in the following section on affordability. These factors include income-generating capacity, amount of remuneration received for products and goods sold or labour and services rendered, and the ratio of the cost of a minimum daily food basket to the average daily income.

Non-market mechanisms include production for own consumption, food preparation and allocation practices within the household, and public or charitable food distribution schemes. For rural people who produce a substantial part of their own food, climate change impacts on food production may reduce availability to the point that allocation choices have to be made within the household. A family might reduce the daily amount of food consumed equally among all household members, or allocate food preferentially to certain members, often the able-bodied male adults, who are assumed to need it the most to stay fit and continue working to maintain the family.

Non-farming low-income rural and urban households whose incomes fall below the poverty line because of climate change impacts will face similar choices. Urbanization is increasing rapidly worldwide, and a growing proportion of the expanding urban population is poor (Ruel *et al.*, 1998). Allocation issues resulting from climate change are therefore likely to become more and more significant in urban areas over time.

Where urban gardens are available, they provide horticultural produce for home use and local sale, but urban land-use restrictions and the rising cost of water and land restrain their potential for expansion. Urban agriculture has a limited ability to contribute to the welfare of poor people in developing countries because the bulk of their staple food requirements still need to be transported from rural areas (Ellis and Sumberg, 1998).

Affordability. In many countries, the ratio of the cost of a minimum daily food basket to the average daily income is used as a measure of poverty (World Bank PovertyNet, 2008). When this ratio falls below a certain threshold, it signifies that food is affordable and people are not impoverished; when it exceeds the established threshold, food is not affordable and people are

having difficulty obtaining enough to eat. This criterion is an indicator of chronic poverty, and can also be used to determine when people have fallen into temporary food insecurity, owing to reduced food supply and increased prices, to a sudden fall in household income or to both.

***Preference**:* Food preferences determine the kinds of food households will attempt to obtain. Changing climatic conditions may affect both the physical and the economic availability of certain preferred food items, which might make it impossible to meet some preferences. Changes in availability and relative prices for major food items may result in people either changing their food basket, or spending a greater percentage of their income on food when prices of preferred food items increase.

Potential impacts of climate change on food utilization: *Nutritional value*: Food insecurity is usually associated with malnutrition, because the diets of people who are unable to satisfy all of their food needs usually contain a high proportion of staple foods and lack the variety needed to satisfy nutritional requirements. Declines in the availability of wild foods, and limits on small-scale horticultural production due to scarcity of water or labour resulting from climate change could affect nutritional status adversely. In general, however, the main impact of climate change on nutrition is likely to be felt indirectly, through its effects on income and capacity to purchase a diversity of foods.

The physiological utilization of foods consumed also affects nutritional status, and this – in turn – is affected by illness. Climate change will cause new patterns of pests and diseases to emerge, affecting plants, animals and humans, and posing new risks for food security, food safety and human health. Increased incidence of water-borne diseases in flood-prone areas, changes in vectors for climate-responsive pests and diseases, and emergence of new diseases could affect both the food chain and people's physiological capacity to obtain necessary nutrients from the foods consumed. Vector changes are a virtual certainty for pests and diseases that flourish only at specific temperatures and under specific humidity and irrigation management regimes. These will expose crops, livestock, fish and humans to new risks to which they have not yet adapted. They will also place new pressures on care givers within the home, who are often women, and will challenge health care institutions to respond to new parameters.

The social and cultural values of foods consumed will also be affected by the availability and affordability of food. The social values of foods are important determinants of food preferences, with foods that are accorded high value being preferred, and those accorded low value being avoided. In many traditional cultures, feasts involving the preparation of specific foods mark important seasonal occasions, rites of passage and celebratory events.

The increased cost or absolute unavailability of these foods could force cultures to abandon their traditional practices, with unforeseeable secondary impacts on the cohesiveness and sustainability of the cultures themselves. In many cultures, the reciprocal giving of gifts or sharing of food is common. It is often regarded as a social obligation to feed guests, even when they have dropped in unexpectedly. In conditions of chronic food scarcity, households' ability to honour these obligations is breaking down, and this trend is likely to be reinforced in locations where the impacts of climate change contribute to increasing incidence of food shortages.

Food safety may be compromised in various ways. Increasing temperature may cause food quality to deteriorate, unless there is increased investment in cooling and refrigeration equipment or more reliance on rapid processing of perishable foods to extend their shelf-life. Decreased water availability has implications for food processing and preparation practices, particularly in the subtropics, where a switch to dry processing and cooking methods may be required. Changes in land use, driven by changes in precipitation or increased temperatures, will alter how people spend their time. In some areas, children might have to prepare food, while parents work in the field, increasing the risk that good hygiene practices may not be followed.

Potential impacts of climate change on food system stability: *Stability of supply*: Many crops have annual cycles, and yields fluctuate with climate variability, particularly rainfall and temperature. Maintaining the continuity of food supply when production is seasonal is therefore challenging. Droughts and floods are a particular threat to food stability and could bring about both chronic and transitory food insecurity. Both are expected to become more frequent, more intense and less predictable as a consequence of climate change. In rural areas that depend on rainfed agriculture for an important part of their local food supply, changes in the amount and timing of rainfall within the season and an increase in weather variability are likely to aggravate the precariousness of local food systems.

Stability of access: As already noted, the affordability of food is determined by the relationship between household income and the cost of a typical food basket. Global food markets may exhibit greater price volatility, jeopardizing the stability of returns to farmers and the access to purchased food of both farming and non-farming poor people.

Food emergencies: Increasing instability of supply, attributable to the consequences of climate change, will most likely lead to increases in the frequency and magnitude of food emergencies with which the global food system is ill-equipped to cope. An increase in human conflict, caused in part by migration and resource competition attributable to changing climatic conditions, would also be destabilizing for food systems at all levels. Climate change might exacerbate conflict in numerous ways, although links between climate change and conflict should be presented with care. Increasing incidence of drought may force people to migrate from one area to another, giving rise to conflict over access to resources in the receiving area. Resource scarcity can also trigger conflict and could be driven by global environmental change.

Grain reserves are used in emergency-prone areas to compensate for crop losses and support food relief programmes for displaced people and refugees. Higher temperatures and humidity associated with climate change may require increased expenditure to preserve stored grain, which will limit countries' ability to maintain reserves of sufficient size to respond adequately to large-scale natural or human-incurred disasters.

Livelihood Vulnerability

The livelihoods perspective is often used as a means of investigating a range of sectors and how they affect individual livelihoods. Viewing food security from a livelihoods perspective makes it possible to assess the different components of food security holistically at the household level.

Livelihoods can be defined as the bundle of different types of assets, abilities and activities that enable a person or household to survive (FAO, 2003a). These assets include physical assets such as infrastructure and household items; financial assets such as stocks of money, savings and pensions; natural assets such as natural resources; social assets, which are based on the cohesiveness of people and societies; and human assets, which depend on the status of individuals and can involve education and skill. These assets change over time and are different

for different households and communities. The amounts of these assets that a household or community possesses or can easily gain access to are key determinants of sustainability and resilience.

Marginal groups include those with few resources and little access to power, which can constrain people's capacity to adapt to climate changes that could have a negative impact on them. It is usually people's few productive assets that are at greatest risk from the impacts of climate change. Physical assets can be damaged or destroyed, financial losses can be incurred, natural assets can be degraded and social assets can be undermined.

The change in seasonality attributed to climate change can lead to certain food products becoming more scarce at certain times of year. Such seasonal variations in food supply, along with vulnerabilities to flooding and fire, can make livelihoods more vulnerable at certain times of the year. Although these impacts might appear indirect, they are important because many marginal livelihood groups are close to the poverty margin, and food is a key component of their existence.

Agriculture is often at the heart of the livelihood strategies of these marginal groups; agricultural employment, whether farming their own land or working on that of others, is key to their survival. In many areas, the challenges of rural livelihoods drive urban migration. As the number of poor and vulnerable people living in urban slums grows, the availability of non-farm employment opportunities and the access of urban dwellers to adequate food from the market will become increasingly important drivers of food security.

A recent International Labour Organization study (ILO, 2005) suggests that there will be significant differences between middle- and low-income countries in the ways in which climate change affects agriculture-based livelihoods. Table 3 shows regional differences in the share of agriculture in total employment and changes in these shares over the past decade. In middle-income countries, a commercialization process appears to be bringing about declines in unpaid on-farm family labour and increases in wage employment.