

ACHIEVING FOOD SECURITY THROUGH
FOOD SYSTEM RESILIENCE: THE CASE OF BELIZE

By

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ABSTRACT

Food provision systems (FPS) have a need for better conceptual and applied tools to evaluate the extent to which they can be made robust and provide a more stable foundation for attaining and maintaining food security in the long-term. The first of three purposes of the thesis is to conceptually design and appraise a more robust FPS resilience framework that integrates the dynamics between ecological, social and economic wealth, connectivity and diversity, and the four basic food security pillars. Based on this framework, the second purpose of this thesis uses Belize as a case study to appraise current food security levels and apply the framework at two distinct scales. The appraisal found Belizean FPS to be highly susceptible to natural hazards, unstable macro-economic conditions, eroding trade preferential treatment, as well as household financial difficulties. In addition, although average national food availability in Belize is above acceptable minimum dietary intake standards, over half the population are indigent or remain vulnerable to food insecurity in several areas. By assessing two major FPS in Belize, findings illustrate (1) how historical patterns and repeated acute and chronic changes have resulted in high proportions of vulnerable and indigent levels in smaller, asset poor, inadequately connected FPS; (2) how FPS have resulted in adaptive cycle pathological traps; and (3) how Panarchy explains why lower-level FPS participants are food insecure, their FPS vulnerable, and their higher-level FPS counterparts rigidly trapped. In fact, this field study effectively demonstrated how the latter constrains the shape of smaller FPS, a large reason why they currently remain vulnerable and indigent. With these FPS complex vulnerabilities in mind, the third purpose of the thesis is to

examine the extent to which Belize's National Food and Nutrition Security Policy can further support a stable foundation for long-term food security through enhancing FPS resilience and social cohesion. For a more FPS resilience-sensitive food policy to be effective, this thesis reveals how to integrate resilience dimensions in food security policies. Overall, the resilience framework allows for a richer description of food security, replacing conventional methods addressing food security status and outcomes, with food security dynamics.

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Chapter 1 – Introduction

1.1 Purpose

Fine et al. (1996) have commented that past food studies have been highly fragmented, according to the approaches traditionally adopted by individual disciplines, and that they have also been lacking in theoretical coherence. The authors argue for greater multi-disciplinary efforts between geography and the other sciences with common interests in food. They further suggest that food systems provide, in their various manifestations, a convenient locus for such sharing, conceptually and empirically, encompassing production through to consumption, and providing links with the spatial conceptions of society. In light of the complexity of food systems, the aim of this thesis is to develop an integrated framework approach to studying food system resilience. The assumption is that the structural problems involved in food systems are the result of complex interactions between alternative food systems in relation to wealth and linkages that include ecological, economic, consumption and social resilience. The purpose of this thesis is divided into three parts:

- (1) Develop a food system resilience framework that integrates the relationships of dynamics between social, economic and ecological systems and thereby provide a more stable foundation for attaining and maintaining food security;
- (2) using Belize as a case study, appraise current food security levels then apply the food system resilience framework at a national and sub-national level; and

(3) examine the extent to which Belize's national food and nutrition security policy can further support a stable foundation for long-term food security through enhancing food system resilience.

Belize was chosen as a case study because of the range of issues that lend themselves to an in-depth assessment of food system resilience. Belize is a rich country with diversified agricultural output and large sectors that are technologically advanced. It is a strong food exporter with a culture, knowledge, and political position supporting a privileged role both in the Caribbean and Central America (EIU 2006). However, current tendencies show deteriorating food systems and resilience, while increasing vulnerability to food insecurity (CSO 2004). For example, average national food availability is above acceptable minimum dietary intake standards (FAO 2006) yet high levels of food insecurity still persist, as over half the population remain vulnerable to food insecurity in many parts of the country (CSO 2004, GoB 2001).

1.2 Research Objectives

The assessment of a food system resilience framework needs to be defined within a clear and operational setting (Fraser et al. 2005). Addressing the overall purpose, this framework will be adapted to the specificity of Belize. This requires the development of a framework to guide the food system resilience assessment, and the application of this framework to contemporary food insecurity issues in Belize. For both the conceptual and applied research, there are three research objectives (RO). For the conceptual segment, the three objectives are:

- RO1- Develop a more robust framework to assess food system resilience (Chapter 2);
- RO2- Review and appraise food security and food system concepts and dynamics to develop food system resilience dimensions (Chapter 3); and
- RO3- Review and appraise implemented methods that assess food security and vulnerability (Chapter4).

The composite conceptual framework will assist in performing the following applied objectives:

- RO4- Describe and appraise current food systems and analyse the food security situation in Belize (Chapter 6);
- RO5- Employ the framework developed in RO1 to diagnose food system resilience in Belize at the sub-national or meso-scale, and national or macro-scale (Chapter 7); and
- RO6- Based upon the results in RO4 and RO5, evaluate the effectiveness of and better inform the current national food and nutrition security policy to address long-term food security needs and issues in Belize (Chapter 8).

1.3 Food System Resilience

A food system includes services such as agricultural *and marine* breeding and production; processing, packaging, and the distribution of food; preparation and

consumption; and food-related waste disposal *and recycling* (Heller and Keoleian 2003, italics added). These food system services, depicted in Figure 1.1, follow a cyclical pattern situated within layered ecological, social and economic wealth, as well as factors of resilience, i.e. the adaptive cycle, steady-state conditions, homeostatic mechanisms and the resilience threshold. The cyclical sustainable food system diagram at the centre of Figure 1.1 is typified by an adaptive cycle and its four system phases, i.e. (r) release, (K) conservation, (Ω) reorganisation, and (α) growth. Situated within the second larger circle are the food system components and services, along with the three food security pillars, i.e. (1) food availability, (2) food access, and (3) food utilisation. The cyclical flow of food system services is maintained by homeostatic mechanisms in keeping the adaptive cycle, i.e. the food system, from crossing the resilience threshold. The threshold can also expand and shrink, evolving and adjusting to resilience components in response to continuous changes affecting food systems. The arrows of the second circle represent the dynamic nature of the resilience threshold. The area within this threshold is characterised by steady-state conditions providing food system stability, known as the fourth food security pillar. Surrounding the resilience threshold and food system are three layers of wealth. The first layer refers to ecological wealth, e.g. agro-ecological conditions, land potential, climate change; while the following layer relates to social wealth, influencing the status of institutions, communities, culture and safety-nets. These two layers encompass a third layer of economic wealth which comprises market components such as capital, labour, credit and trade, as well as productivity, infrastructure and poverty. The food system relies significantly on these three resilience components to ensure long-term food security.

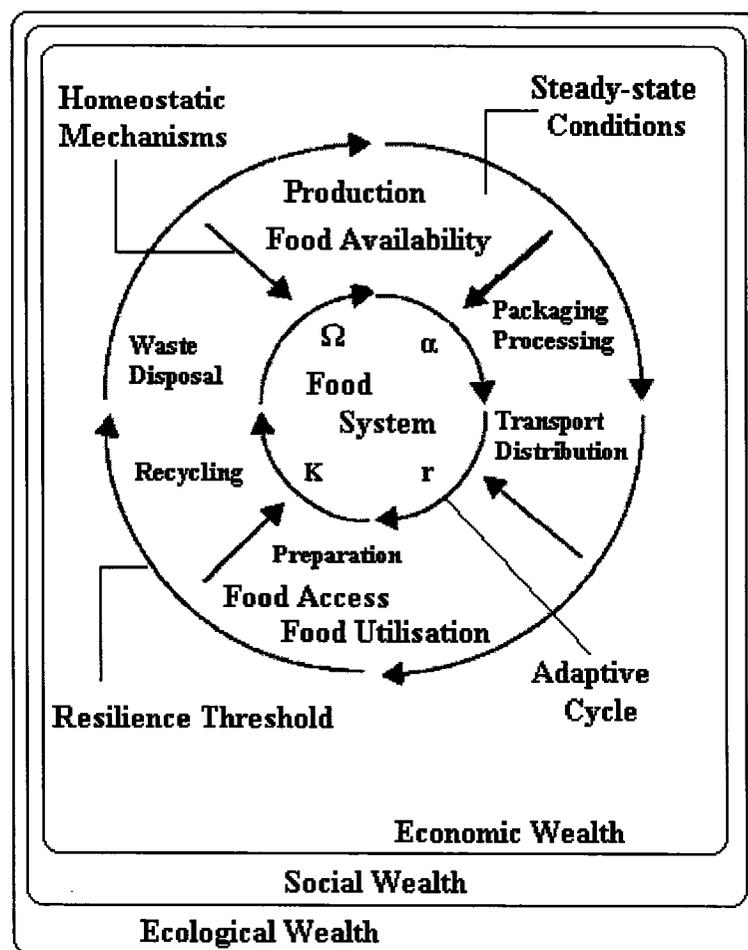


Figure 1.1 – An illustration of a sustainable food system represented at the centre by an adaptive cycle and its four system phases portrayed in a cyclical pattern, i.e. (Ω) release, (α) reorganisation, (r) growth and (K) conservation. This cyclical design of the food system is a key characteristic of sustainability. The cyclical flow of food system services, along with food security pillars, are maintained by homeostatic mechanisms to keep the adaptive cycle from crossing a given resilience threshold. The area set by this threshold is characterised by steady-state conditions providing food system stability. Lastly, surrounding the resilience threshold and food system are three layers of wealth: (1) ecological, (2) social, and (3) economic, wealth upon which the food system relies to ensure long-term food security. Own design inspired from Bonnard (1999), Garcia (1984), Gunderson and Holling (2002), and Hill (1982).

A key characteristic of cyclical food system design is its sustainability (Hill 1982).

Sustainability is the capacity to continue a desired condition or process *within a dynamic, evolving system* (adapted from Tainter 2006). A food system that is sustainable fosters equitable food production, distribution, consumption, and broader economic development opportunities (von Braun and Brown 2003). For instance, creating an equitable food system involves improving access to land and other natural resources crucial to production; developing access to technology, physical infrastructure, and to local and international markets; developing greater labour productivity; and investing in improving food system participants' education and status, particularly among women (Pinstrup-Anderson et al. 2001).

Consequently, the food system's desired process or sustainable goal is to ensure food security, defined as providing food and services to ensure affordable, safe, culturally appropriate and nutritious sustenance at all times to all people, produced in ways that are environmentally sound and socially just, in a manner that promotes human dignity (adapted from Fairholm 1998). Sustainable food system services thus strive to ensure food security and foster equity. However, longer-term food system sustainability will result not from movement along a smooth cyclical trajectory but rather from the continuous adaptation through homeostatic mechanisms to changing conditions in which growth, transformation and stability are common conditions along food system adaptive cycles. To adapt, such food systems require innovation and adjustment reaching congruity between ecological, economic and social wealth. Such requirements can be met through resilience theory.

Resilience is the capacity of a system to experience change while retaining essentially the same function, structure, feedbacks, and therefore identity (Walker et al. 2006), maintaining food system properties and services. It is a concept that has been highlighted in recent research aimed at understanding abrupt change in managed resource systems (Berkes et al. 2003, Holling 2001, Holling and Gunderson 2002, Holling et al. 2002, Walker et al. 2004), and is increasingly being applied to food systems from a theoretical perspective (Fraser et al. 2005 (urban food systems), Fraser 2003 (Irish potato famine), Løvendal and Knowles 2005 (food security and risk management), Pingali et al. 2005 (complex crises and food emergencies), and Tainter 2006 (complexity)). It is important, however, to distinguish resilience from sustainability, or the capacity to prolong a desired condition. If a food system is tenable and conditions steady, this definition follows Holling's (1973) notion of resilience, i.e. the capacity of a system, or amount of disturbance a system can absorb without shifting into an alternate state (Walker et al. 2006), or a regime shift (Carpenter 2003, Kinzig et al. 2006, Scheffer et al. 2001) that may be reversible, irreversible, or effectively irreversible, i.e. not reversible on time scales of interest to society.

Food systems exhibit economic, ecological and social thresholds that, when exceeded, result in changes in food system properties and services, thus impacting sustainability and levels of food security. The system is said to have undergone a dissipative change (Garcia 1984). The more resilient a food system, the larger the disturbance it can absorb without shifting into a new dissipative state. It is important to understand resilience when it

transpires. Latent resilience is expressed, i.e. passive resilience becomes active, when there is food system degradation leading to food insecure conditions either through small changes, sharp shocks, or gradual cumulative change from either chronic and structural factors. Resilience is thus about resisting disorder and potential rehabilitation by returning to, or maintaining system functions. Nevertheless, it may not always be positive. Food system resilience, in recovering its functions, can potentially mean abandoning its sustainability goal of food security, and the economical, social and or ecological values that underlie them (Tainter 2006, *italics added*). Thus sustainability and resilience can conflict (Allen et al. 2003) as resilience of an untenable food system, e.g. depleted of natural resources, is contrary to sustainability. For instance, a particular food industry may have such high sunk-costs or non-recoverable fixed costs, that it may continue to degrade the natural resource it relies upon until its ecological wealth is totally removed. High resilience here would mean a great ability for the system to resist external disturbances and persist due to, and remaining as, a degraded ecological system (Allison and Hobbs 2004), accompanied by food insecure conditions.

This thesis offers a novel approach of how a food system can achieve its sustainability goal by retaining functions and services through food system resilience when experiencing change, the latter defined as growth, transformation and continuation along a food system cycle. This requires viewing food systems as closely coupled with social, ecological, and economic wealth (Figure 1.1) at different scales, ranging from inputs and individual commodities, products or process scale, to consumption across system-wide scales at community, regional or global levels. In this view, food system resilience

captures the sustainability of natural, anthropogenic and socio-ecological systems (Dale 2001, Robinson and Tinker 1997). As a result, the research analysis of this thesis will apply this novel approach to address food system resilience both at a national scale and at a sub-national scale in Belize.

1.4 Food Systems Complexity

Contemporary food systems are increasingly complex. With increasing complexity comes increasing costs. These costs include labour, investments, technology and time that are needed to create, maintain, and replace systems that grow in demand, have more components, institutions, regulation, information, waste, and degradation. For example, in the history of human food-gathering and production, labour-sparing hunting and gathering gave way to more labour-intensive agriculture, which in some places has been replaced by costly capital-intensive industrial agriculture that consumes more energy than it produces (Boserup 1965, Clark and Haswell 1966, Cohen 1977). Marx (1906, in Zwart 1999) further argued that food products generated by capitalism represented social costs, basic items of concern, and incarnations of social tension and conflict, consequently increasing complexity in the food system. A more modern example of costs from complex food systems are revealed by severe forms of food insecurity. For instance, the manifestation of malnutrition is the convergence of poverty, unemployment, disease and illiteracy, rapid population growth, and environmental degradation; these in turn are linked to cultural factors, economic distortion, human inequities, and social injustice (Swaminathan 2003). Thus numerous determinants of food insecurity include both costly food and non-food factors (Dutta et al. 2004). Tainter (2006) adds that societies have

changed from egalitarian relations, economic reciprocity, ad hoc leadership, and generalised roles, to social and economic differentiation, specialisation, inequality, and full-time leadership. Such characteristics are the essence of complexity, and they increase the cost in any food system.

And as those costs grow, the point is reached where further investments in complexity and ecological, economic and social wealth aspects of the food system do not give a proportionate return. This is a tipping point when change in food systems can occur. SSC are transformed as incremental investments in complexity begin to yield smaller and smaller returns. Consequently, the marginal return, i.e. the return per extra unit of investment, starts to decline preparing the food system for a distinct adaptive cycle rotation, eventual dissipative shift, and transformation of the food system. Given that food system sustainability is a long-term goal, food security degradation and increased food system complexity should not be allowed to proceed unchecked, as they will eventually bring ineffective solutions, wealth stagnation, and ultimately make societies and systems vulnerable to collapse (adapted from Tainter 1988, 1999). A prolonged period of diminishing returns from increases in system complexity is a major part of what makes problem-solving ineffective, societies or institutions unsustainable, and food systems untenable. But how do we imagine better futures when food systems involved are complex and deeply interconnected?

1.5 Moral Challenges

Because food insecurity in its many shapes and forms is avoidable, current food system failures present us with many moral challenges. Following Shue's (1980) description of basic social rights, the food system ensures a minimal commitment and obligation to meet a basic human need to which adequate food is a precondition to welfare and public health. This follows Rawls' difference principle in his theory of social justice: only those differences in wealth (and duty, *added*) would be justified which enabled the least well-off to be better off than under any other arrangement. John Locke (1690, as reported in Johnson 1996) argued that natural reason shows that every person has a right to food and drink and such necessities, and to their own property, at least where there is enough, and as good, left in common for others. In addition, based on egalitarian theory, many natural rights and ethics had been written using such sources as Jean-Jacques Rousseau's Social Contract from the mid 18th century, e.g. the French *Déclaration des droits de l'Homme*. Contract theories are useful in showing that we are more likely to help others if we see ourselves as part of a reciprocating scheme of social cooperation (Dower 1996), and social cohesion (Qadeer and Kumar 2006), arguably an utopian view (Beitz 1979), however, one where old relationships are rethought (Busch 2003) and where institutions, e.g. the United Nations Food and Agriculture Organisation (FAO), have a role to play (Busch 2003, Hendrickson et al. 2001, Kloppenburg 2005, Macer et al. 2003). And for those incapable of representing themselves, e.g. vulnerable groups such as infants, the elderly, and potentially plants and livestock, duties to protect those at risk are made indirectly by contractors within the food system, those who understand and accept the contract, often with sentimental interests for their welfare, thus building food system

resilience by fulfilling its social contract. An equitable food system avoids agents being beneficiaries at the expense of others, as it takes action to prevent coercion and deception (Dower 1996, O'Neill 1986, Taylor 1988) offering security which extends out towards the whole food system across cultures and societies (Rawls 1971). For instance, to ensure food security, vulnerability to market fluctuations and political manipulation should be reduced (Garcia 1984). Added to this view are utilitarian concepts of benevolence: the system's services provide food not only for the well-being of system participants but of self (Jonas 1979, Singer 1971), by reducing the potential for food insecure conditions to occur, and by ensuring resilience of tenable systems.

By addressing the wealth aspects of resilience, a food system can reach the above goals, e.g. by promoting adequate incomes for producers; local and global diverse food production based upon agro-ecological principles; by offering protection of local agricultural lands and fish habitat; by ensuring widespread access to healthy and nutritious food; and through social cohesion, allowing for the reduction of disparities, inequalities, and social exclusion. If the food system cannot deliver food and services on which people depend, sustainability declines, food system degradation occurs and the probability of becoming food insecure rises. Food system failures are occurring as U.N. FAO (2005) official figures show nearly one billion people suffer from food insecurity. Senauer and Sur (2001) believe this figure to be much higher as entire populations remain either food insecure, or vulnerable to food insecurity, i.e. susceptible to future harm from the outcome of food system changes.

1.6 Previous Research in Integrating Resilience in Food Security and Food Systems

Internationally, the definition of food security stemming from the 1996 World Food Summit is: Food security exists when all people at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life (FAO 1996). This definition integrates stability, access to food, the availability of nutritionally adequate food, and the utilisation of food. Food availability refers to the physical presence of food at various levels from individual, household to national level, whether from own production or through markets. In fact, food security is often still only understood as the adequate physical supply of food (food availability) (IFPRI 2005, Maxwell 1990, Osmani and Azad 1998, Riely et al. 1995). Food access refers to the ability to obtain an appropriate and nutritious diet and is linked to resources at the household level. Food utilisation relates to individual level food security and is the ability of the human body to effectively convert food into energy. 'At all times' signifies stability, a temporal component, which points to the need for understanding both current and likely future status at different points in time (Løvendal and Knowles 2005). A framework for analysing food security must capture these temporal dynamics.

While food security is an outcome, food system resilience is process-driven and strives to maintain food system functionality and therefore, food security outcomes. Food system resilience lessens acute, transitional, seasonal, cyclical and chronic variations in food

consumption, access and availability, as well as providing longer-term efforts to preserve stability and means of production. Resilience's four dimensions to be introduced in this thesis, i.e. ecological, economic, consumption and social, are required to suitably analyse food security within a food system resilience framework which examines relations and interactions between food system provisioning processes. This kind of analysis has a dynamic historical dimension which distinguishes it from static exercises centered on a simple description of the flow of food products from producer to consumer at a specific time (Chattopadhyay and Spitz 1987). Food systems are thus considered to reflect a shifting balance of power within society as resources are differentially allocated to the task of providing an acceptable minimum standard of consumption. In researching food system resilience, the explanation cannot be boiled down to an analysis of production indices or economic indicators as Garcia (1984) argues, but rather both in (1) food system property relationships and how these evolve over time, and (2) in food related policies.

Resilience is dynamic and socially produced (Watts and Bohle 1993, Dixit 2003). It is the capacity to manage, adapt to, cope with, or recover from risks, i.e. events, trends and structural factors that threaten food supplies, access or utilisation (Pingali et al 2005). This requires, as Collinson (2003) explains, a new set of questions and a philosophical and cultural shift in practices and outlooks, a research endeavour pursued in this thesis and represented by the food system resilience framework. In addressing resilience, a growing body of research on the non-linear complexity of food insecurity, and vulnerability to food insecurity, must be taken into account. Using an example of a societal response to flooding, Dixit (2003) makes the case that low resilience determines

beforehand why certain sections of societies are more vulnerable to change than others. The author contends evidence from a number of case studies point to the fact that the asset poor (i.e. with weak economic wealth) at the margins of the region's social, economic and political system (i.e. through weak social wealth), often suffer from natural hazards (i.e. ecological wealth impacts) because of their asymmetric and hierarchal socio-economic relationships within those wealth layers. This suggests that both food insecurity, and vulnerability to food insecurity, of people in risk-prone food systems can be addressed by improving wealth availability and access, thereby enhancing food system resilience.

In the literature, the concept of vulnerability is used with different connotations. A fundamental difference exists between (1) vulnerability as defencelessness vis-à-vis harmful change, e.g. vulnerability to hurricanes; and (2) vulnerability to a specific negative outcome following such change, e.g. vulnerability to food insecurity (Løvendal and Knowles 2005). Much of the disaster management literature uses vulnerability with reference to a natural hazard (Alwang, Siegel and Jørgensen 2001), while the food security literature and part of the social risk management and poverty literature (Barrett 2005, Dercon 2001, Holzmann and Jørgensen 2000, Mansuri and Healy 2001) define vulnerability in terms of an unfavourable future outcome. Humanitarian aid and disaster management tend to focus on rapid responses focused on alleviating vulnerability and food insecurity in the short-term. On the other hand, vulnerability relative to a social welfare outcome, is concerned with guaranteeing a minimum food secure welfare-sensitive threshold, through short- as well as longer-term measures. This thesis focuses

both on the latter concept of vulnerability to a specific negative outcome, and long-term responses related to food security.

Under short-term conditions, there is little or no difference between food insecure outcomes today or tomorrow. However, over longer periods of time, some food system participants move in and out of food insecurity and vulnerability. Vulnerability is defined relative to the negative outcome of food insecurity and refers to food system participant's propensity to fall, or stay, below a food security threshold within a certain time frame. Vulnerability of people, places and food systems to food security change is an overreaching concept encompassing elements of resilience, or the capacity to anticipate, cope with, resist and recover from stresses and perturbations. However, past models of vulnerability have been outcome-based, e.g. examining the multiple causes of a single outcome; or disruption-specific, e.g. dealing with a single hazard or event; and have not been sufficiently applied to social processes and ecological interactions as causal agents, nor to reducing structural and systemic vulnerability or increasing resilience (Adger et al. 2005, Bankoff 2003, Dixit 2003, Ribot 1995, Watts and Bohle 1993, Webb and Rogers 2003, Wisner et al. 2004). Understanding these analytical challenges through food security and food system resilience research can help identify a resilience range or band of tolerance while reducing susceptibility to said change, i.e. increasing both stability and sustainability. This thesis proposes to draw upon these concepts of resilience to bridge food system vulnerability and food security research, as well as addressing these and other analytical challenges more fully in Chapter 5.

Other scientists have also argued that new thinking is needed to develop an analytical framework to articulate, describe, and understand the reflexive relationship between humans and the environment (Kasperson et al. 2001, Smith 2001). The analytical challenge is combining social and ecological theory and data in meaningful ways which respect the differences between coupled systems and allow for more complexity (Bar-Yam 1992, Kauffman 1992, Tainter 2006). Climate change scholars have investigated such issues, defining resilient communities or social wealth, for instance, as a way of identifying regions that may be adversely affected by ecological fluctuations (Adger and O’Riordan 2000, Carpenter et al. 2001, Haneremann 2000, Reilly and Schimmelpfennig 1999, and Smit et al. 2000). This thesis attends to these additional analytical challenges through resilience theory by addressing the interactions between coupled socio-economic and ecological systems, and mapping adaptive cycles by food security thresholds onto the resilience framework proposed in this research.

However, to properly tackle the complexity of social, economic and ecological systems, sustainability must continue to move towards a model that is both process-driven and dynamic (Newman 2006) and any study of complex adaptive systems (typical of food systems) must itself be evolutionary and dynamic. Moreover, both system uncertainties and continuing innovation are required. Such a model has been developed through resilience theory, a model framework adopted in this thesis to effectively achieve the conceptual and empirical purposes set out in Section 1.1. By definition, resilience theory includes the larger-scale processes of connectivity and linkages between social, ecological *and economic* systems (Holling 2001, Nyström and Folke 2001, italics added).

Through assessments addressing interactions between human activities and the environment at the interface of land and water, Payet and Obura (2003) found that resilience theory explicitly provided for scaling up from local to regional and even global scales, and for traversing ecological and social boundaries to enable the cross-linking of actions that will be necessary to deal with the threats of change to systems. Additionally, Obura (2005) similarly found resilience theory (1) provided a unifying conceptual framework for research on natural and threat-induced changes on systems, (2) helped develop management responses from local to regional scales, and (3) offered a way to understand social consequences and drivers of change.

Based on the promising research results pertaining to resilience theory presented in this chapter, this thesis will verify how resilience theory can be developed conceptually and applied as a diagnostic tool to (1) empirically assess and appraise food system dynamics, and (2) to evaluate the extent to which food systems can be made more sustainable and food secure in the long-term.

1.7 Thesis Structure

Food system, food security, and resilience concepts presented in this introduction are intertwined and only offer a complete picture in combination. A guiding research framework of the thesis is presented in Table 1.1. It provides an overview of the chapters, their progression and shows the research questions to be addressed.

This thesis is composed of nine chapters. Following this introduction, Chapters 2, 3 and 4 make up the conceptual basis of the thesis. Chapter 2 starts with the development of a more robust framework modeled after resilience theory to assess food system dynamics. In Chapter 3, food security and food system concepts, ending with a core set of four food system resilience variables matching each of the four food security pillars, will be presented and appraised. Selected implemented approaches to assess food security and vulnerability will then be appraised in Chapter 4 venturing to inform the food system resilience framework. Tying the conceptual and empirical stages of the thesis is Chapter 5, a bridging chapter, which summarises the analytical tools, scale of analysis, and data sources used during fieldwork.

Chapters 6 and 7 make up the empirical segment of the thesis. Current food system and food security conditions in Belize are assessed in Chapter 6 while the food system resilience framework developed in Chapter 2 will be applied in Chapter 7 to diagnose food system resilience based upon results from Chapter 6. This case study then sets the foundation in Chapter 8 for articulating the key resilience constructs informing Belize's national food and nutrition security policy in a way conducive to reducing food insecurity in a sustainable manner. In the conclusion, Chapter 9 reflects upon the concept of food system resilience, contemplates the knowledge gained, and provides potential extensions from the research conducted.

Table 1.1 - Guiding framework showing key research questions and the progression through the thesis by chapter.

How are sustainability, resiliency, food systems and food security related? How are food systems dynamic and complex? How have past methods addressed food system structural problems involved around complex interactions among subsystems that include ecological, social and economic wealth?	Chapter 1	Introduction
What is a more adequate framework for integrating longer-term vulnerability into food security analysis paying more attention to chronic structural food systemic issues, system relationships and resilience? How are food system functions preserved and rebuilt within a complex, interconnected and non-linear framework, where outcomes are uncertain and faced with constant change factors? What is resilience theory? Where are food poverty thresholds situated?	Chapter 2	Resilience Theory: A More Robust Framework for Assessing FPS
What are current broad food security and vulnerability concepts? How are food systems defined? How are FPS structured to strengthen food security with many competing purposes and priorities as agents of change exercise leverage over sustainability, restructuring, and transforming FPS? What are appropriate variables in measuring adaptive cycles? How do food system properties interact?	Chapter 3	Concepts and Dynamics - Situating Food Security and Food Systems; Food System Resilience Variables Identified
How are vulnerability, risks, food security and FPS linked? How do current practical approaches assess FPS vulnerabilities?	Chapter 4	Vulnerability and FPS Assessments
Summary of the analytical tools, scale of analysis, and data sources used during fieldwork in Belize	Chapter 5	Bridging Chapter (between the thesis' conceptual and empirical segments)
What are current Belizean food system features? Are causes of food insecurity rooted in the colonial socio-economic systems, a post-colonial preferential trading system, and a dominant paradigm of national wealth creation through international economic competitiveness? How do history, migration and remittances relate to FPS and resilience? What are current methods used and what food security measures are obtained? What are the different thresholds of food poverty such as indigent line?	Chapter 6	Assessment of the Belizean Food Provision System and Current Status of Food Security in Belize
Apart from its colonial past, what are the major agents of change on FPS in Belize (macro-economic conditions, erosion of trade preferential agreements, natural hazards)? What are the sub-national, national and regional factors affecting food security in Belize?	Chapter 7	Empirical Application of Food System Resilience Theory to Belize
How does resilience further inform food policy in achieving food security, a sustainability goal of the food system? How do food systems persist and adapt? How relevant are the internalisation of risk, appropriateness of scale and social cohesion? How does Belize's current National Food and Nutrition Security Policy address FPS resilience?	Chapter 8	Evaluation of Contemporary Belizean Food and Nutrition Security Policy to Address Food System Resilience
Review of research results and thesis' purpose, along with extensions from the research conducted	Chapter 9	Conclusion

FPS = Food provision systems

Chapter 2 - A More Robust Framework for Assessing Food Systems

Frameworks for integrating longer-term vulnerability into food security analysis are largely non-existent (Haddad and Frankenberger 2003, Løvendal and Knowles 2005, Webb and Rogers 2003), and most vulnerability analyses, often applied in the context of early warning systems and emergency food security assessments, focus on transitory, short-term and acute change in preparing humanitarian responses. Thus, less emphasis is placed on identifying and analysing the potential longer-term impacts of change to food security, i.e. events, trends and structural factors that threaten the stability of food supplies, food access or consumption (Pingali et al 2005), which require a set of interventions different from emergency or humanitarian responses. In light of this research gap, the aim of this chapter is to build a framework for assessing food system resilience to food insecurity. The assumption is that the structural problems involved in food systems are the result of complex interactions among subsystems that include ecological, social and economic wealth (Dale 2001, Robinson and Tinker 1997). This chapter applies to complex food systems what is now understood as resilience theory based upon the way natural systems behave (Gunderson and Holling 2002) as the application of resilience theory addresses the food system need and research gap for developing better conceptual and applied tools (Fraser et al. 2005) to evaluate the extent to which food systems can be made more sustainable and ensure greater food security.

2.1 Adaptive Cycles

2.1.1 The Four Phases

Over time, the structures and functions of systems change as a result of internal dynamics and external influences, resulting in four characteristic phases which constitute the adaptive cycle (Holling 1986, 2001). Walker et al. (2006) describe Holling's four phases and the adaptive cycle (Figure 2.1) as follows: first is the growth (r) phase, characterised by readily available resources, the accumulation of structure, and high resilience, i.e. greater food system ability to resist change, maintain food system properties and services. As structure and connections among system components increase, more resources and energy are required to maintain them. The second phase is one in which net growth slows and the system becomes increasingly interconnected, less flexible, and more vulnerable to external change. This is described as the conservation (K) phase. These two phases, r and K , called the foreloop, correspond to ecological succession in ecosystems and constitute a development mode in organisations and societies. Disturbances in the conservation phase and the crossing of tipping points lead to the next phase, a period of release (Ω) of bound-up resources in which the accumulated structure collapses, followed by a reorganisation (α) phase, in which novelty can take hold, and leading eventually to another growth phase in a new cycle. The new growth phase may be very similar to the previous growth phase, or it may be quite different. These two phases, Ω and α , are referred to as the backloop. The exit from the cycle indicated at the left of Figure 2.1 suggests a stage where wealth can leak away and where a shift into a less productive, connected, and wealthy system occurs.

Many systems appear to move through these four phases, including ecosystems (Holling 1986), social systems (Westley 2002), institutional systems (Janssen 2002), and social-ecological systems (Allison and Hobbs 2004, Gunderson et al. 1995, Holling et al. 2002). Figure 2.1 below is a stylised representation of the four systemic functions or phases (r , K , Ω , α) and the flow of events among them. The arrows show the speed of that flow in the cycle, where short, closely spaced arrows indicate a slowly changing situation and long arrows indicate a rapidly changing situation. The cycle reflects changes in wealth, on the Y-axis, and connectivity on the X-axis. Wealth is inherent in the accumulated structure and includes (1) economic wealth, e.g. monetary, assets/entitlements, labour; (2) social wealth, e.g. political and cultural; and (3) ecological wealth, e.g. physical, natural wealth, i.e. depicted as wealth layers in Figure 1.1. The difference in wealth activity on the Y-axis shows that with decreasing wealth from passive to active, wealth activity increases, i.e. with diminishing absolute wealth, wealth intensity increases as remaining wealth is incrementally exhausted and reused, such as labour following losses in social or ecological wealth. On the X-axis, weak connectivity is associated with diffuse elements loosely connected to each other whose behaviour is dominated by outward relations and affected by outside variability. Strong connectivity is associated with the concentration of system components whose behaviour is dominated by inward relations among components, relations that control or mediate the influence of external variability. This can be assessed by measuring how connected the components of the system are to each other, to external systems, and over time. Figure 2.2 shows a three dimensional version with resilience as the third axis while Table 2.1 shows the level of each of the three variables on Figure 2.2 that characterise the four phases of the adaptive cycle.

Figure 2.1 - A stylised representation of the four system functions and the flow of events among them (adapted from Gunderson and Holling 2002).

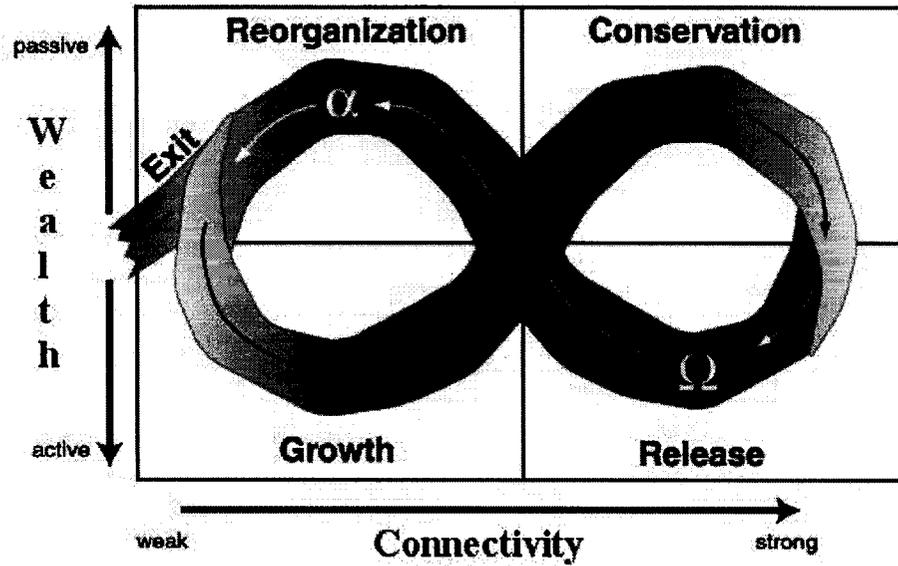
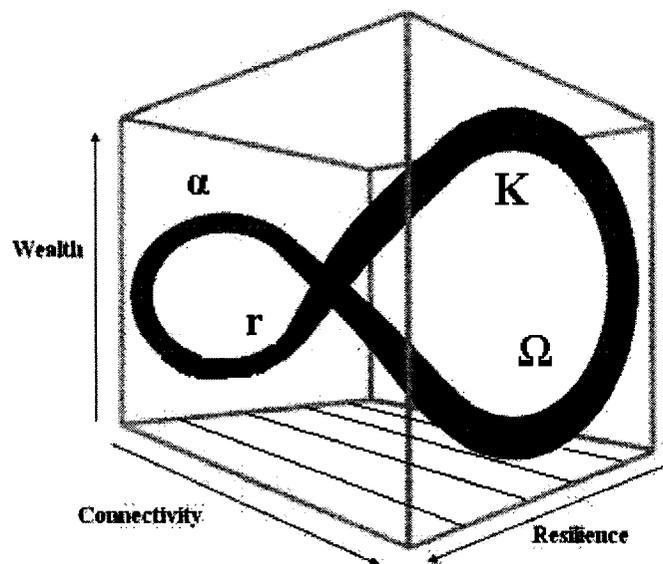


Figure 2.2 – Three dimensional model of the adaptive cycle. Resilience expands and contracts throughout the cycle in relation to wealth and connectivity among the system phases (adapted from Gunderson and Holling 2002).



Reorganisation (α)		Conservation (K)	
Wealth	High	Wealth	High
Connectivity	Low	Connectivity	High
Resilience	High	Resilience	Low
Growth (r)		Release (Ω)	
Wealth	Low	Wealth	Low
Connectivity	Low	Connectivity	High
Resilience	High	Resilience	Low

Source: Gunderson and Holling (2002)

Table 2.1 – Level of each of the three adaptive cycle properties (wealth, connectivity and resilience) that characterise the four phases of the cycle. The table adopts a four-quadrant configuration mimicking the metaphor of the adaptive cycle.

2.1.2 Adaptive Cycle Traps

If each of the three properties in the adaptive cycle (wealth, connectivity, and resilience) is given two nominal levels, either low or high, then the adaptive cycle model uses only four of a possible eight combinations of the three adaptive cycle properties, i.e. normal flow of conditions (Table 2.1). The other four combinations are suggested as pathological states, i.e. a deviation from normal flows, departures from the adaptive cycle. The levels of the three properties of each trap are given in Table 2.2 below. The poverty trap (Holling et al. 2002) is characterised by all three properties having low values, creating an impoverished system. Untenable maladaptive poverty traps, as demonstrated by numerous resource systems that exist in a constant or recurring state of crisis, have been common throughout human history (Ludwig et al. 1993, Tainter 1988).

Pathological State	Wealth	Connectivity	Resilience	Table 2.2 – High and low level properties of the three variables that characterise the four pathological states (adapted from Allison and Hobbs 2004).
Poverty trap	Low	Low	Low	
Rigidity trap	High	High	High	
Lock-in trap	Low	High	High	
Structural trap	High	Low	Low	

The second pathological state, the rigidity trap (Holling et al. 2002), may apply to social systems in which the members of organisations and their institutions become highly connected and inflexible. For example, rigidity traps occur over time in bureaucratic systems or nation's economies focused on a few key commodities. Holling et al. (2002) contend that one example of a rigidity trap may be found in agro-industry, where management has squeezed out diversity, and where power, politics, and profit have reinforced one another, increasing connectivity, consequently maintaining resilience artificially high. Export-oriented food systems may fall into this trap, by maintaining economic, social and ecological wealth away from less connected lower-level alternative adaptive cycles, such as food systems focused on traditionally-led domestic agriculture and that do not take part in foreign trade. For instance, changes in hurricane intensity and frequency would severely impact tourism and export crops, e.g. banana, sugar, and citrus, while changes in institutional and market flexibility may provide an effective means to cope with these changes while reducing further degradation of the natural resource base or ecological wealth.

The third pathological state, the lock-in trap, can be described as follows: if a region's resilience is achieved by substituting direct reliance on regional factors with institutional intervention and sophisticated technology, often generated at the global scale, then this substitution gives the perception of an adaptive resilient system. Technological advances make single variable interventions or create interventions without regard for their impacts on other parts of the system (Allison and Hobbs 2004). This has been described as the human propensity to focus on single cause-and-effect solutions, a means-ends logic designed to solve a particular problem (Westley et al. 2002), with serious implications for continued resource misuse. For instance, as a solution is found for each problem, it will create side effects, perverse and unintended effects, potential externalities (Costanza et al. 1997), e.g. costs to food system services, stability and sustainability, and can lead to resilience path dependencies maintaining a lock-in pathological state.

For example, agricultural intensification involving changes in technology largely masks the degradation of natural resources and has resulted in perceived stability of the system (Allison and Hobbs 2004). Novelty in technology effectively redefines the system and prevents the whole system from crossing critical thresholds, changing from one state to alternative dissipative states. Even with the ability to redefine the system by creating novel futures through technological advances, this system will still rely on a continuous stream of new technologies, institutions, or social adaptations to add resilience and maintain the adaptive capacity, rendering the systems untenable in the long-term.

Further connectivity can emerge from complex systems of relationship and dependence between system components, e.g. producers and the agro-industry they support. This

increased connectivity is represented within a lock-in pathological state, which, in economics, describes an industry that has so much non-recoverable fixed costs that it may continue to degrade the resource it relies upon until its ecological wealth is totally exhausted. The lock-in pathological state has low potential for change, high connectivity, and high resilience. High resilience here would mean a great ability for the system to resist external disturbances and persist due to, and remaining as, a degraded ecological system.

The last pathological state listed in Table 2.2 is proposed in this thesis as a 'structural trap,' characterised by (1) a high potential for change, typified by available wealth forms which are either not accessible, e.g. either through untapped ecological wealth due to the lack of physical access, or currently appropriated land from higher-level adaptive cycles; or undervalued, e.g. economic wealth such as labour and knowledge; (2) low connectivity, highly affected by outwards relations and variability; and (3) low resilience, supporting repeated losses of system functions and little if any absorption capacity to externalities; caught in a backloop of recurrent reorganisation, and unable to develop novelty, nor system relationships. The chronic food insecure and malnourished may be found here with "labour *and knowledge* as their last, possibly only, and most likely devalued, assets *or accessible forms of economic wealth*" (Christoplos et al. 2004, italics added). Nutrition is an engine of labour productivity as important as technical agricultural inputs (Bonnard 2001). Therefore, malnourishment can render the food insecure unable to build economic wealth through time and across generations, perpetuating the adaptive cycle in a pathological structural trap.

2.2 Relationships across Larger and Smaller Adaptive Cycles

2.2.1 Scale

Studies conducted at different scales and places reveal varying faces of change and societal impacts, they also focus attention on the interactive processes that link phenomena among global to local scales (Moser 1998). Using a meso-scale approach provides connections and cross-scale interactions between such higher-level and local-level scales (Easterling 1997, Schmandt and Clarkson 1992). Assessments of such cross-scale interactions and linkages between adaptive cycles provide insight into the structure of food systems, producing knowledge that is more integrative and therefore solutions that are more encompassing of food system components affected by change.

Analysis by scale provides particular insights into the importance of demographic, political, economic, social and technological changes in determining the impacts of change on food systems in time and space. Hence, regional and local studies need to be situated in an open system (Kasperson et al. 1995, 1996). Moreover, Wood (1990) argues, as do Watts and Bohle (1993), that credible analyses of the causes and effects of change will need to be multi-layered and spatially-structured. In addition, studies of the hazardousness of place (Hewitt and Burton 1971) and ecology of small-scale areas (Blaikie and Brookfield 1987, Turner et al. 1990), and of common-property governance (Jodha 1992, Lane 1998, Ostrom 1990, Ostrom et al. 1999), speak of the many ways by which humans transform ecological, social and economic wealth, perpetually shaping multi-layered food systems.

A multi-layered and spatially-structured framework of societal response also mixes both biogeophysical processes and human driving forces such as population growth, land-use change, global political economy, and societal values (Kasperson et al. 2001). Such a framework is intended to identify cyclical and iterative processes and feedback loops characteristic of both food systems and resilience theory represented in this thesis by adaptive cycles. Therefore, it is necessary to conceptualize and identify the main adaptive cycles within the framework at different scales affected by changing conditions through time. Consequently, the significance of relationships between any two sets of adaptive cycles resides not only in the scale of wealth accumulation (*and increase in power, capital, entitlements*), productivity and employment, but also in their capacity to stimulate the economy as a whole due to their backward and forward linkages (adapted from Bernini Carri 1987). Cannon (2002) suggests that these linkages are determined by several factors, two of which are of particular significance, profit-seeking, and subsistence farming for the majority, as defined globally by hundreds of millions of peasant households found throughout the impoverished world (Pretty 1995). These linkages, interactions and hierarchies between these two sets of adaptive cycles at a country level form the founding argument of this thesis.

2.2.2 Hierarchical Confinement and Panarchical Relations

Cross-scale interactions can reveal hierarchical systems, that is, systems that can be analysed into successive and related sets of subsystems (Gunderson and Holling 2002, Simon 1962). The systems are represented in this thesis by cycles that have been termed

high-level and low-level adaptive cycles. This way, hierarchical systems display a special type of nested orderliness, each having particular resilience properties (Peterson 2000). There is also a simultaneous spatial dimension where current actions of one group affect the current well-being of another group (Dixit 2003) through panarchical relationships between adaptive cycles at a national and sub-national scale, e.g. export-oriented food systems at a higher-level dissipative structure, over lower-level traditionally-led food production oriented food systems. Typically, these spatial externalities are asymmetrical, if not entirely unidirectional (Lélé 1998), benefiting the higher-level structure. And as Steiner (1998) points out, what is needed is the knowledge of the agro-ecological, socio-economic and institutional conditions prevailing in a place-based setting.

Food systems have structures and functions that cover wide ranges of spatial and temporal scales. However, most structures are not scale invariant but occupy discrete domains in space or time (adapted from Walker et al. 2006). All of these structures are posited to change in the adaptive cycle phases described in Section 2.1 at a given scale. Structures and processes are also linked across scales based on the interactions between two sets of adaptive cycles: (1) higher-level, broader but slower structures and processes, and (2) lower-level structures and processes that are faster and smaller. These interactions between sets of adaptive cycles can be characterised as either hierarchical confinement or panarchical relations. Panarchy Theory (Gunderson and Holling 2002) represents a subset of resilience theory applied to cross-scale relationships between adaptive cycles and dissipative states. Panarchical relations suggest that both top-down and bottom-up interactions occur, while hierarchical confinement is demonstrated when slow, broad

features constrain and shape the smaller, faster structures (Allen and Starr 1982, Gunderson and Holling 2002, O'Neill et al. 1986). The dynamics of a food system at a particular scale of interest, i.e. the focal scale, cannot be understood without taking into account the dynamics and cross-scale influences of the processes from other food systems at scales above and below it. Recent work on resilience suggests that many of the observed shifts, crises, or non-linearities observed in ecological systems are from processes and structures interacting across scales (Gunderson and Holling 2002, Walker and Meyers 2004).

Figure 2.3 is a representation of panarchical relations and hierarchical confinement between two adaptive cycles. Each level or focal scale experiences its own adaptive cycle dynamics, within the constraints of the broader, slower hierarchical levels. However, at key moments, the normally weak interactions across levels are strengthened. When the faster and smaller cycle enters its release phase and experiences a collapse, it may influence the next larger and slower level by triggering a crisis in that level's conservation phase. This effect is shown by the 'Revolt' arrow, the condition where fast and small events overwhelm slow and large ones. The arrow labelled 'Remember' indicates the second cross-scale interaction important at times of change and renewal. For example, once an adverse event takes place, the opportunities and constraints for the renewal and reorganisation of the lower-level adaptive cycle are strongly conditioned by the conservation phase of the above larger and slower focal level.

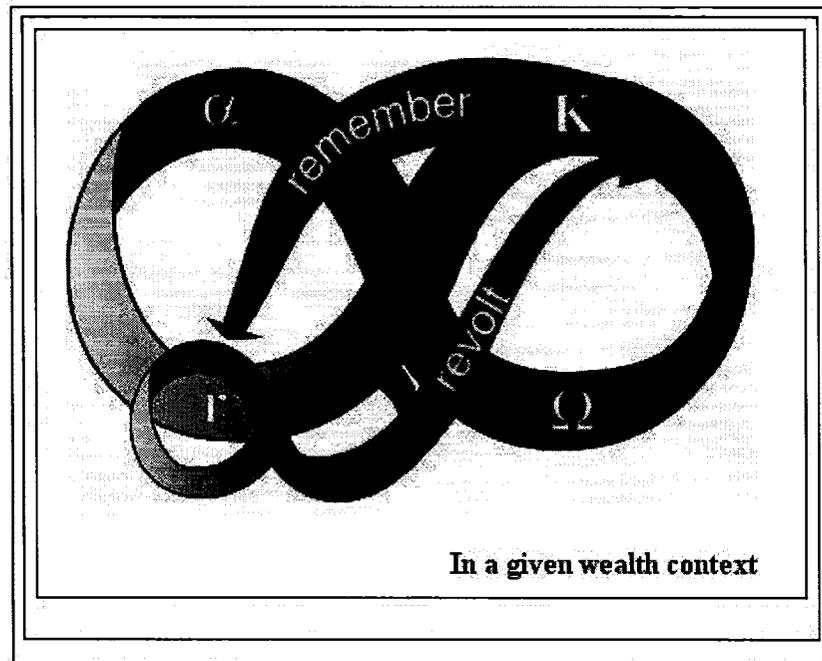


Figure 2.3 - Panarchical relations between two adaptive cycle levels showing Memory (remember arrow) or hierarchical confinement, and Revolution (revolt arrow).

Surrounding the two adaptive cycles or food systems are the three layers of wealth: ecological, social, and economic. Adapted from Gunderson and Holling (2002).

2.2.3 Dissipative States and Steady-State Conditions

Given any previous state, the structural properties of a given food system tend to evolve towards steady-state conditions (SSC). The adaptive cycle configuration and its properties do not change with time (Garcia 1984), within normal conditions, that is, the food system maintains its functions, services and structure. This follows Holling's (1973) notion of resilience as the amount of disturbance a system can absorb without shifting into an alternate self-organised system. If a disturbance is large enough, however, an

adaptive cycle may cross over resilience thresholds, departing from normal SSC. These resilience thresholds, upper and lower food system resilience limits of a resilience band, constitute the area outside SSC. Disturbances introduced into the system provoking change (departure from SSC) may be such that the system returns to similar SSC by a succession of phases: if not, a novel dissipative state is developed. Food systems within SSC have mechanisms of response to change, generating internal forces or resilience opposing and adapting to change, called homeostatic mechanisms (Garcia 1984). These forces are responsible for system stability, maintaining food system services and the capacity to remain within SSC. Increased or amplified changes to functional components may push them beyond a certain threshold, outside its resilience band, and take the food system and thus the adaptive cycle away from SSC. This occurs when exiting the adaptive cycle at the reorganisation phase as indicated at the left of Figure 2.1. It is characterised by a stage where wealth has leaked away and where a shift into a less productive, connected and wealthy system occurs as the systemic structure is no longer steady, leading the system to new SSC. The system thus acquires a new structure and configuration, called a dissipative structure (Garcia 1984), which is then kept stable if the fluxes and conditions are kept constant.

Dissipative change represents an entire shift of the adaptive cycle, an entirely novel self-organising system, an adaptive cycle with renewed hierarchical confinement and panarchical relations with its previously more juxtaposed adaptive cycles, i.e. food systems joined more narrowly by shorter panarchical relationships and similar resilience characteristics. Recapturing the concept of resilience theory, each juxtaposed adaptive

cycle represents a separate food system pertaining to specific groups of food system participants, who differ for instance, by culture, vulnerability, or location. Explained differently, many adaptive cycles may be found using the same food system within similar scales and SSC, however, where each group's food system or adaptive cycle is situated depends upon their system's level of ecological, economic and social wealth, level of connectivity, as well as resilience. These are the properties and structure of their respective food system. However, once change is large enough to destabilise a food system's SSC, the evolution of the process is no longer determined by the said change, but by the nature of the system, properties of the structure, and the behaviour proper to each group of food system participants. Each adaptive cycle will respond differently. Even small changes may provoke large departures from SSC, producing dissipative (lower-level) structures.

For example, Albers et al. (2006) consider producer decisions in a shifting cultivation system that contains a critical threshold for the regeneration of soils (ecological wealth). Once the threshold is crossed there is an irreversible shift from forest to grassland, i.e. new SSC. They consider the role of prices in inducing such a shift. If producers are encouraged to crop land for extended periods, the food system's ecological capacity to regenerate is reduced enough for invasive grasses to establish, hence reducing both the ecological and economic wealth of the food system. More importantly, the authors consider the combined effect of foresight (significance of this potential dissipative shift) and incentives. Results show that policies that subsidise the cost of production, or that enhance producer prices, can have opposite effects on the producers' well-being and food

security, depending on the information available to them. Producers who are not aware of the potential for dissipative shifts may be induced to take actions that cause the shift. Conversely, policies that improve productivity or the rate of forest regeneration reduce the risk of such a dissipative shift.

In sum, food systems, as adaptive cycles, exhibit limits above and below a resilience band or SSC that when exceeded result in changed system feedbacks that lead to changes in function, services and structure. The system is said to have undergone a regime shift (Carpenter 2003, Scheffer et al. 2001) resulting in a dissipative state that may be reversible, irreversible, or effectively irreversible, i.e. not reversible on time scales of interest to society (Walker et al. 2006). The more resilient a system, the larger the disturbance it can absorb through homeostatic mechanisms without shifting into an alternate regime. This is why analysis must go beyond measuring and describing state variables or outcome measurements, e.g. food security status, but rather processes such as resilience.

2.3 Building on Existing Resilience Theory

2.3.1 Transformation and Self-Organisation

Walker et al. (2006) define resilience as the capacity of a system to experience shocks while retaining essentially the same function, structure, feedbacks, and therefore identity, and argue that the state of a system at any one time can be defined by the values (and relationships, added) of the components that constitute the system. The dynamics of the system are reflected as its movement through the resilience framework. Different

adaptive cycle configurations in which the system has the same controls on function, i.e. the same feedbacks, and essentially the same structure, each represent similar SSC within the same system or regime. Configurations in which the types and intensity of feedbacks differ, and in which there are different internal controls on function and system services, each represent different system regimes and thus dissimilar SSC and thresholds.

Regimes with different configurations can have significantly different implications for society and may be considered desirable or undesirable (Walker et al. 2006). Desirability can be expressed in economic terms (Carpenter and Brock 2004), in ecological terms (Walker and Meyers 2004), and in social terms (Scheffer et al. 2000, 2002). Using a combination of all three terms, desirability for food systems can be expressed in resilience terms, that is, ensuring food security by maintaining food system services, functions and structure. As adaptive cycles are subject to small constant changes and large acute changes, they adjust and persist to maintain system services and functionality through homeostatic mechanisms. Consequently, these cycles must express resilience. It is feasible that some system regimes may be considered desirable by one segment of society and undesirable by another, from profit seeking to subsistence agriculture, as argued by Cannon (2002). Furthermore, certain regimes that are considered undesirable can also be very resilient, such as those found in a locked-in pathological state. In addition, very low resilience may lead the system towards unstable dissipative states, potentially irreversible (Reggiani et al. 2001) found in poverty or structural pathological states.

Using soil conservation as an example, Antle et al. (2006) focus on the role of prices in inducing shifts or transitions between SSC in a given food system. In their case study, the determinant of the transition between SSC is the level of investment in soil conservation, driven by the return to that investment. They argue that the system has two SSC: one of high productivity maintained by investment in soil conservation, and the other, characterised by low-productivity, where there is no investment in soil conservation. According to the authors, the threshold level of soil degradation (loss of ecological wealth) is the point at which returns to investment in soil conservation become negative. In this case, there is nothing in ecological wealth that is irreversible – in the sense that investment in soil conservation could bring the system back up to the high productivity SSC. However, they argue that it is economically irreversible, in that, at the expected price, a rational producer has no incentive to change their decision not to invest. This reflects an externality in which the transition between SSC is the unintended consequence of decisions based on price (economic wealth) that do not reflect the forward costs / benefits ratio of soil conservation nor the dissipative shift towards a pathological state of the lower-level productive food system.

Undesirable regimes and dissipative shifts can be represented through transformability. It is the capacity to create a fundamentally new system when the existing system is untenable (Walker et al. 2004). For instance, the transformation of a social-ecological system can be a response to the recognition of the failure of past policies and actions, triggered by a resource crisis, or driven by shifts in social values (Gunderson et al. 1995). Social-ecological systems can sometimes get trapped in very resilient but undesirable

regimes in which adaptation is not an option. For instance, agricultural growth drivers produce high levels of output and keep costs of commodities low though there is the potential over time for one or more ecological, economic and social costs to develop in other parts of the food system. They may take form as resource depletion (use exceeds regeneration), environmental pollution (waste generation), and social decline (income loss) (Sawin et al. 2003), and as they place limits on production, the ecological wealth degradation of the FPS resilience framework raises resilience to such a state it becomes maladaptive and can no longer adapt. Ultimately, the ecological wealth dimension will become severely impoverished as the variables and FPS participants in the commodity system become more tightly connected, causing the resilience to increase because the system has reached such a degraded state that it is extremely stable. Escape from such regimes may require transformative forces from large external disruptions or internal reformations to bring about change (Holling and Gunderson 2002). These forces are incorporated into the resilience framework through connectivity, in an effort to internalise external processes into the adaptive cycle configuration or by provoking a revolt when lower-level cycles experience a collapse overwhelming higher-level adaptive cycles.

Resilience is a systems concept, addressing the ability of a system to undergo change but retain the same functions and general structure (Holling et al. 1995). This requires memory within the system that stores information and makes it available for innovation and maintaining SSC (Holling 2001, Nyström and Folke 2001) within resilience thresholds. Systems may have multiple SSC, to which they may trend away after perturbations from one of the previous states. Depending on the strength of the

perturbation away from SSC, the system may return to it, or it may gravitate towards a different one. A system that tends to return to similar SSC even after major perturbations has high resilience. A system that has crossed resilience thresholds above or below SSC, has low resilience and will shift towards and self-organise into an alternative adaptive cycle. Thus resilience of a system requires some capacity for memory, which enables it to be self-organising and return to a steady state (Walker et al. 2006). Self-organisation is achieved through homeostatic mechanisms, such as memory, exemplified by components of ecological wealth (Levin 1999), e.g. seeds or rainfall, or institutional or indigenous knowledge in social systems, residing in laws and institutions, or widely shared ideologies and values. In other words, adaptive cycles at one level can be repeated if higher-level adaptive cycles of the Panarchy provide memory, and the role of memory is strongest when the higher-level adaptive cycle is in the conservation (K) phase (Walker et al. 2006). Such panarchical linkages across scales between sets of adaptive cycles provide top-down opportunities for memory from the higher-level adaptive cycles to influence and renew lower-level adaptive cycles, potentially constraining innovation in these adaptive cycle configurations in their self-interest. For instance, dissipative adaptive cycles can emerge when memory is disrupted because higher-level adaptive cycles are themselves in a backloop, or even in an early growth phase (r), with many system trajectories still possible (adapted from Walker et al. 2006).

As hinted earlier, resilience can be applied to social as well as ecological systems (Folke et al. 2003, Holling 2001), the common property being the capacity for self-reorganisation. However, can aspects of resilience, as developed in context of ecological

systems, be transferable to social-economic systems? And can the coupled resilience framework developed around food system dynamics in this thesis be used to examine and explain both social-economic and ecological systems?

While complex ecological adaptive systems are generally characterised by self-organisation without system-level intent, humans have the capacity for foresight and deliberate action. Self-organisation in complex social-ecological systems is therefore somewhat different from that of purely ecological or physical systems (Westley et al. 2002). It can be argued that, although the dynamics and direction of change in socio-economic systems are influenced by food system participants that have intent, the food system as a whole does not. However, because human actions dominate social-economic systems, the adaptability of such systems is mainly a function of the food system participants influencing and managing them. Adaptability in this case is the capacity of the participants in a system to manage resilience (Walker et al. 2006). Their actions affect the degree of system resilience, either intentionally or unintentionally (Berkes et al. 2003) while their capacity to manage resilience with intent determines whether they can successfully avoid crossing resilience thresholds into an undesirable dissipative system or succeed in crossing into desirable SSC towards food secure adaptive cycles.

Human intent distinguishes the dynamics between a coupled social-economic and ecological system and a purely ecological or physical system. Policies, management, investments, safety-nets and other actions can deliberately avoid crossing food system resilience thresholds. Nonetheless, undesirable ecological wealth losses are often created

through attempts to maintain preferred social adaptive cycle configurations, e.g. salinised agricultural systems (Anderies 2005). If persistent, a lock-in pathological trap may occur requiring transformative forces to provoke self-organisation of a new adaptive cycle. By and large, dynamics will vary across ecological, economic and social systems. However, such dynamics show similar characteristics such as scale, thresholds, memory, self-organisation and cross-scale linkages. Consequently, it is argued that food system dynamics in linked social-economic and ecological systems can be addressed in a coupled resilience framework as assembled in this thesis.

2.3.2 Diversity

Diversity is another characteristic of adaptive cycles, SSC and food systems. Diversity provides a way of assessing the capacity of the system to adapt to external forces as diverse systems are better able to tolerate a wide range of environmental, (economic, added) and social conditions than simple systems (Gunderson and Holling 2002, Fraser et al. 2005). A growing number of case studies have revealed the tight connection between resilience, diversity, and the sustainability of coupled socio-ecological systems (Adger et al. 2001, Berkes and Folke 1998). Indeed, the more alternative system functions and services are capable of responding to system disturbances, or change episodes, the greater a system's resilience.

Using irrigated systems, for example, Sengupta (2006) shows how a fragmented pattern of landholdings can create much greater diversity than would otherwise have been the case, and how this and social cooperation enhances food system resilience. The author

considers the role of fragmentation in irrigated agriculture in India. In this case, fragmentation is not the result of inheritance laws, but reflects producer's creative participation in irrigation schemes. The author found that diversity of management strategies increases the resilience of the food system, and concludes that it is difficult to design diversity because it reflects the adaptive response of many different producers.

However, uncertainties remain for all three food system resilience wealth forms. For instance, at the ecological level, natural rainfall varies. Water is received from distant areas through the canals though when and how much is unknown. Consequently, groundwater levels vary, they may be depleted. At the social level, political and social conflicts are reflected in the local area; on some issues individual actions come into conflict with food system requirements. Interactions too are uncertain. Food system participants' labour cooperation may be partial and insufficient. However, these participants have devised varieties of resilience instruments for containing the effects of uncertainties, e.g. the use of captive storage to reduce fluctuations in water availability (ecological wealth); and a wide variety of crops (diversity) are grown to reduce chances of crop failure. However, the crucial food system link to resilience is social cooperation. Without the cooperative organisation, water, the renewable resource cannot be used sustainably. Similarly, Sengupta et al. (2000) depicted how producers were able to withstand a wide set of uncertain external disturbances and threats to the food system, as they invested in building effective local institutions of cooperation to improve resilience. However, there may exist thresholds beyond which their adaptive cycle and food system

cannot self-organise while facing irreversible change as cooperation may collapse, provoking a dissipative shift to self-organise under new SSC.

In relation to system dynamics and SSC, Walker et al. (2006) recognize two kinds of diversity: (1) functional diversity, i.e. the number of functionally different groups, which influences system performance, and (2) response diversity, i.e. the diversity of types of responses to disturbances within a functional group, which influences resilience.

According to the above authors, performance in self-organised ecological or physical systems is related to the diversity of functional groups of species, such as with productivity in savannas, enhanced by having grasses, nitrogen-fixing forbs, shrubs, and trees with different rooting depths (Scholes and Walker 1993); in coral reefs, enhanced by fish grazing algae, grinding dead coral, and eating urchins, each type in a different functional group (Bellwood et al. 2004); and in simplified agro-ecosystems, through multi-cropping systems. In social systems Walker et al. contend performance is related to the diversity of functional actor groups: the more different types of actors there are, the more functions are performed. The second diversity type is the diversity of responses to disturbance among species or actors contributing to the same function in coupled social-economic and ecological systems, i.e. functional redundancy. Resilience is enhanced by response diversity as demonstrated by Elmqvist et al. (2003) using examples from forests and lakes, to coral reefs. Walker et al. (2006) found some evidence that functional redundancy in resource governance contributes to resilience in the form of response diversity in coupled socio-economic and ecological systems. Furthermore, overlapping governance structures can enhance the resilience of such coupled systems to external

ecological or social shocks and add to the resilience of adaptive cycle governance (Berkes et al. 2003, Dietz et al. 2003, Folke et al. 2005, Ostrom 2005). However, Walker et al. (2006) conclude that efforts to increase the efficiency of production in agro-ecosystems tended to focus on removing apparent redundancies and thereby reduce resilience.

Resilience degradation can take many forms. Holling et al. (2002) proposed that an adaptive cycle ceases to be adaptive when wealth and diversity have been eradicated by misuse or an external force, as illustrated by the degradation of savannas entering an irreversible eroded state (Holling and Gunderson 2002). Human activity such as agriculture can further mine resources (see Passioura 1999 for an example from soils) leading to a lock-in pathological state, in which the land manager is under increasing pressure to produce more, while the economic return from the land diminishes, either because of lowered productivity, land degradation, and or reduced terms of trade.

In ecological systems, Lawton (2000) and Loreau et al. (2001) synthesised the evidence from many experiments and affirmed that the diversity of functionally different species affected the rates of stability and increased the reliability of ecosystem processes locally. Furthermore, a number of observations suggest that biodiversity at larger spatial scales, such as landscapes and regions, ensures that appropriate key species for ecosystem functioning are recruited to local systems after disturbance or when environmental conditions change (Bengtsson et al. 2003, Peterson et al. 1998). In this sense, biological

diversity provides insurance, flexibility, and risk spreading across scales in the face of uncertainty and thereby contributes to ecosystem resilience (Folke et al. 1996).

Wealth, diversity and connectivity ensure the resilience of systems, that is, their ability together to adapt to new conditions (Perrings 1998, van den Bergh and Gowdy 2000). It then follows that evolving socio-economic systems may also be described as being more or less resilient, in terms of being adaptable to economic changes and environmental changes, due to the redundancy or lack of wealth and connectivity present in them (adapted from van den Bergh and Gowdy 2000). Levin et al. (1998) indicate that socio-economic and spatial systems have to be sufficiently resilient when addressing new challenges and sudden qualitative shifts, though it is usually difficult to detect strong signals of change (i.e. release) early enough to motivate and induce effective solutions and system responses. Levin et al. (1998) state that systems need to be flexible and adaptive, whereas Holling (1973) argued that in ecological and socio-economic systems alike, human activities can lead to qualitative shifts in system structure and function, evidence that the system concerned has lost resilience. In this case, the system is no longer capable of absorbing the stresses and shocks imposed by human activity without undergoing a fundamental change involving loss of function and, often, accompanying loss of productivity. Resilience is, according to Holling, both the ability to experience change and disturbances without catastrophic qualitative change in the basic functional organisation, and a measure of the system's integrity and relative stability.

2.3.3 Resilience Bands

Resilience is a dynamic readjusting pattern that is characterised by multiple directions and magnitudes, as it changes with transformations to and within the adaptive cycle.

Resilience persists and adapts (Adger 2003b). Resilience persists in achieving a sustainable desired form, e.g. a food system achieving food security; and adapts, given forms of wealth, i.e. ecological, social and economic. This thesis introduces the concept of bands of tolerance. Such resilience bands applied to food systems are new to the resilience literature as it differs from adaptive cycle; with levels of resilience fading and increasing, and consequently steady-state conditions, following adaptive cycle transformations. SSC, as interpreted in the previous section, fall within these upper and lower thresholds of the resilience band.

In this context, Perrings (1998) makes a distinction between absorbing SSC (greater capacity, longer-term) and transient SSC (in development, shorter-term). As the probability that a system in one state will change to an alternative state increases, the less resilient the system is in the previous state. Absorbing states are more resilient than transient states as they assimilate increased levels of wealth and connectivity to function through enhanced homeostatic mechanisms. This can be illustrated through actions to counter increases in both vulnerability to food insecurity and superior food insecurity levels as adaptive cycles approach resilience thresholds. Participants in a set of adaptive cycles will attempt to satisfy production to consumption requirements by adapting to local conditions and dieting (transient SSC) long before the vulnerable and food insecure resort to absorbing SSC such as wealth expenditures of productive assets, or even

migration, a form of connectivity (adapted from Watts 1983). It also follows that the system will evolve from less resilient transient groups of states to more resilient absorbing groups of states (Perrings 1998). Another way of describing this transition is that the food system will get locked-in to a particular group of absorbing states and bands of tolerance as productive assets are exploited, or further growth in connectivity is redundant. In its future evolution, the system will involve only alterations between states in the latter absorbing SSC.

Non-linear dynamic food systems, affected by exogenous components, represent systems whose behaviour is not expressible as a sum of the behaviours of its food system components. As resilience is defined with respect to SSC, stability around the latter continues to be relevant even after incorporating non-linearity (Lélé 1998), meaning system components which do not behave in a similar fashion to the system. In general, for a system to be able to persist over time, an attribute of connectivity, it requires that it be at or around some SSC and express either transient resilience, i.e. stability in the face of smaller perturbations, or absorbing resilience, what will be called structural resilience henceforth, i.e. adaptation in the face of larger perturbations, at worst provoking dissipative adaptive cycle regime shifts. The two forms of resilience above may be termed differential resilience, or the combined homeostatic mechanisms, in reaction to the severity of, and the susceptibility to, actual and potential future changes in adaptive cycles.

Differential resilience can be measured as the band of tolerance as shown in Figure 2.4 below, as sensitivity of a food system to environmental hazards for instance, is expressed as a function of the variability of geophysical elements and the degree of aggregate ecological, social, and economic resilience. The band of tolerance is located between the upper and lower damage thresholds (Figure 2.4). Within the band of tolerance, events are perceived as having normal and average SSC, and transient resilience maintains the system within the band. Beyond (above and below) the damage thresholds, they are perceived as hazards as structural resilience is required to assist the adaptive cycle around the four phases back to conservation following release, reorganisation and growth, while avoiding dissipative shifts by maintaining the adaptive cycle within SSC thresholds. The area between the thresholds represents an acceptable range of variation for the magnitude of a variable (SSC), for example annual rainfall. Most socio-economic activities are geared to some expectation of average conditions (and larger potential changes). Remaining within these thresholds, the ecological wealth is perceived as beneficial. However, when the variability exceeds some threshold beyond this band of tolerance, thresholds which guide the adaptive cycles within the band, the same variable starts to impose damage and becomes a hazard even a disaster (loss of normal SSC). In this example, very high or low to no rainfall will be deemed to have created a flood or drought respectively (Smith 2004).

The two dimensions in Figure 2.4 are spatial and temporal: the magnitude of the natural resource on the vertical scale and time on the horizontal scale. It follows that the risk of

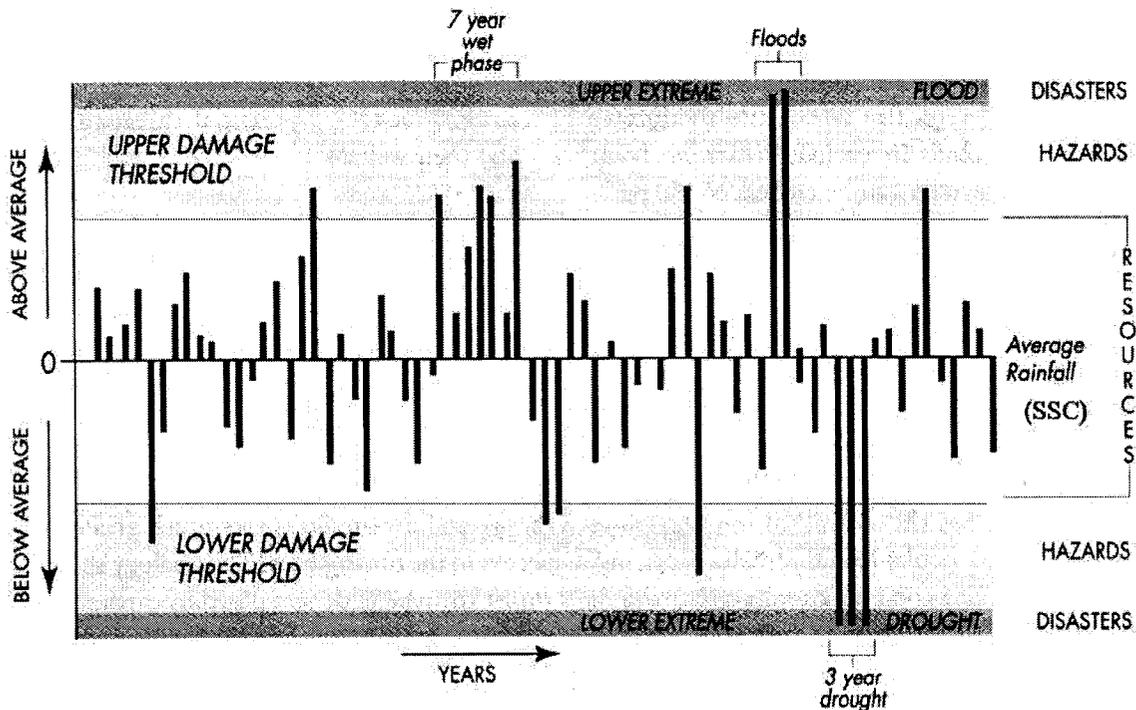


Figure 2.4 – Differential resilience as a band of tolerance to a physical element across time, e.g. annual rainfall (Smith 2004, adapted from Hewitt and Burton 1971). The area between the thresholds represents an acceptable range of variation under normal conditions (SSC).

this potential natural hazard may vary through time with changes in system resilience or band of tolerance at various scales. Some possibilities which give rise to increased risk are shown in Figure 2.5. Case A represents a constant band of tolerance and constant factor variability but a decline in the mean value (e.g. decrease in rainfall, temperature, soil quality), aggravating for instance, soil conditions over time, though the band remains firm (e.g. adaptive cycle lock-in pathological trap) as the adaptive cycle refers constantly to structural resilience, e.g. through improvements in drought tolerance. A larger constant

band and mean, Case B differs by an increase in variability (e.g. larger fluctuations in rainfall) where resilience reverts between transient and structural conditions. Finally, in Case C, variability does not change but the band of tolerance narrows as resilience erodes, e.g. vulnerability increases as population growth has put more people at risk to food insecurity. In this case, system vulnerability is greatest at the margins of tolerance, as even small environmental changes will have great impacts.

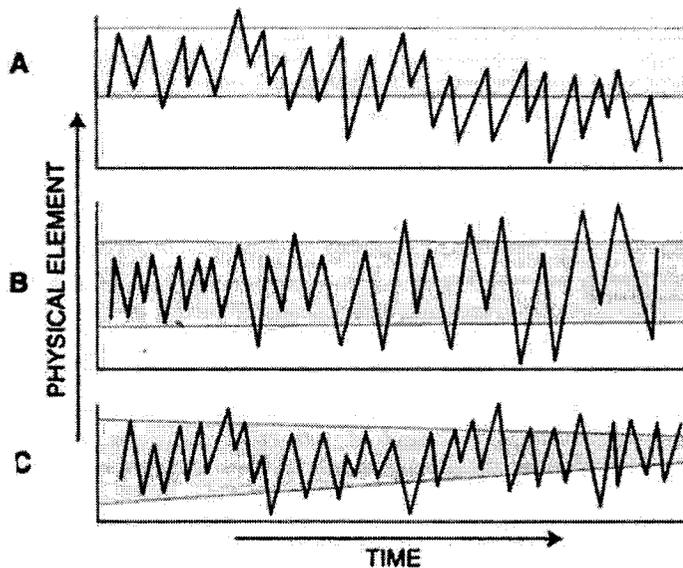


Figure 2.5 – Variability of change factors and bands of tolerance (Smith 2004, adapted from de Vries 1985). The physical element is independent for all three cases, it does not increase from Case C to Case A, it increases within each case.

To better grasp the relationships between the adaptive cycle model portrayed in Figures 2.1 and 2.2, the resilience bands in Figures 2.4 and 2.5 and the food system in Figure 1.1, annual rainfall is used as an element of ecological wealth to capture the food system resilience dynamics of a single adaptive cycle presented across this chapter. As Panarchy reflects the relationships between adaptive cycles, neither Figure 2.3 nor Panarchy are discussed here. The food system portrayal in Figure 1.1 allows for a food system, represented by its adaptive cycle, to move freely around the food system resilience

framework within the area between the resilience thresholds. This area represents an acceptable range of variation of wealth and connectivity under normal conditions, also called SSC. A food system thus revolves through the adaptive cycle's four characteristic phases with changing wealth, e.g. ecological, social and economic; and connectivity factors, e.g. time, access, control and enfranchisement. Each form of wealth has both a resilience dimension and threshold, above and below the adaptive cycle, establishing a band of tolerance for each resilience dimension. The band of tolerance depicted in Figures 2.4 and 2.5 only relates to the ecological resilience dimension of the food systems resilience framework. Annual rainfall thus represents both a necessary form of food system ecological wealth and a segment of overall adaptive cycle wealth. Changes in rainfall will affect the entire adaptive cycle while other wealth forms and connectivity factors constrain and hasten its impact, as part of the overall homeostatic mechanisms to maintain food system SSC. Over time, potential changes to the ecological resilience band of tolerance are shown in Figure 2.5.

The adaptive cycle also moves in time across the food system resilience framework depicted in Figure 2.4. The figure also shows the direction in which the entire adaptive cycle may have moved, with increases and losses in ecological wealth, in a particular year. It is an indication of the historical path the adaptive cycle has taken purely from an ecological resilience standpoint. A more aggregated and comprehensive view of overall resilience would require overlaying similar resilience patterns for social and economic wealth. Moreover, separate food systems will have distinctive adaptive cycles with their respective thresholds and bands of tolerance. Comparing an adaptive cycle's band of

tolerance patterns to those of alternative adaptive cycles thus addresses panarchical relationships and aggregated behavioural aspects of resilience.

2.4 Applying Resilience to Food Systems

2.4.1. Aspects of Resilience

What a resilience analytical framework adds is an assessment of the current state of health of a system and its capacity to withstand changes (Lau et al. 2003). How can food security be ensured given a particular state of food system resilience to change? A food system is all-embracing where causes and effects, interactions and inversions, linear *and non-linear* chains and feedback loops are mixed in an integrated, complex whole (Garcia 1984, italics added). A change in such a system may be generated in any subsystem and lead to modifications in all other adaptive cycle components through the chain of interactions and positive or negative feedbacks. The complexity of a given system depends on its components and the connections among its components. Thus it highly depends on how interrelations are defined among the components of a system. These connections determine the structure of the system and provide the conditions to consider the components under a structured entity such as the food system. As a non-linearly structured entity, the system has properties which do not result from the addition of its components' properties. In fact, an essential point to make is that the most significant aspects of the evolution of a system come from changes in its structural properties (Garcia 1984), i.e. the relationships among its components and panarchical relationships across adaptive cycles.

According to Pingali et al. (2005), within complex emergencies, the intervention strategies that will augment system resilience should be based on the following principles: (1) strengthening diversity; (2) re-building local institutions and traditional support networks; (3) reinforcing local knowledge; and (4) building on food system participant's ability to adapt and reorganise. According to Berkes and Folke (2002) and Scheffer et al. (2000), the focus ought to be on reconstructing the capacity of provider communities to find rapid, flexible solutions to problems and to balance power among the various interest groups and stakeholders. The focus of this thesis is not on complex emergencies at the tactical or operational side of resilience but rather on how to address the structural aspects of resilience at a strategic level (organisation of a robust food system to build long-term food security). An overview of resilience is suggested in Table 2.3 (OSU 2006) below, with resilience divided into both functional and structural aspects, and strategic and tactical levels. At the strategic level, concerns over the adaptive cycle rest with robustness of the system over time and scales that can be measured in years, such as for ecological wealth. At this level, functional resilience involves understanding strategic threats or opportunities and developing innovative responses, while structural resilience involves organising the system to build resilience to change. At the tactical or operational level, efforts are focused upon the continuity of the system over shorter time scales. In this case, functional resilience involves the agility in recognising and resolving short-term problems, while structural resilience involves establishing safeguards against large disruptions and hazards.

Level	Functional (Sense, Respond)	Structural (Organize, Build)
Strategic (Robustness)	Adaptation Innovation Transformation	Fortification Connectivity Diversification
Tactical or Operational (Continuity)	Recognition Resistance Recovery	Redundancy Flexibility Security

Table 2.3 - Multiple Aspects of Resilience.

Source: Adapted from OSU 2006.

Resilience provides a compromise in that it offers simple diagnostics of complex systems (Walker et al. 2006). Resilience needs to be defined within a clear conceptual and operational framework (Pingali et al. 2005) and requires clearer frameworks to assess wealth, diversity and connectivity (Fraser et al. 2005). An initial appraisal of the applied framework by Fraser et al. reveals that: (1) complex adaptive systems may be compared through time and scale; (2) these adaptive systems can analyse complex and unpredictable or unanticipated patterns and feedback loops; (3) systems differentiate between endogenous conditions (i.e. local economic factors and biophysical indicators) and exogenous forces (i.e. fluctuations in the global market or climatic variation); (4) systems start with the premise that disturbance and change are normal; and (5) complex adaptive systems integrate social variables and environmental factors while relating vulnerability concepts towards explaining complex human-environmental relations. However, the scope of their analysis is limited to urban food systems (excludes subsistence and non market-integrated agriculture) or only takes into account concepts of entitlements, mostly related to the food access and somewhat less on food availability.

Further work is required tying these observations to food utilisation and stability, as food security and food systems are much broader and require a more comprehensive analysis. Wealth in the Fraser et al. study is constrained to economic terms when this resilience property must include the other wealth forms, both social and ecological. Though, the ecological perspective of their approach is insightful, the relations across the three characteristics are not sufficiently explicit. They should be treated together, over time and scale.

2.4.2 Thresholds

Stability in terms of stable food systems represents a cross-cutting issue that affects all components of a spectrum from food insecurity, to vulnerability, to food security. With increased uncertainty comes heightened vulnerability: the higher the vulnerability, the greater the probability of becoming food insecure as food system resilience is increasingly less able to resist and absorb externalities and change. Vulnerability also refers to the probability of falling below a food system threshold, or the probability regarding the failure to attain a certain threshold of well-being in the future, in this case, food security over time. While the vulnerable in praxis are often implicitly understood to be those with a probability of becoming food insecure above a certain pre-determined threshold, no standard exists that defines this threshold (Løvendal and Knowles 2005).

If the probability of being food insecure is higher than being food secure, this is considered the 50 percent probability threshold (Christiaensen and Subbarao 2005, Tesliuc and Lindert 2004). Expressed differently, participants within a food system along a particular adaptive cycle or food regime, are classified as vulnerable if they have a

greater than 50% chance of falling below a particular food system measure in the future. For the purpose of this thesis, this cut-off point between the food secure and the vulnerable to food insecurity, refers to food systems, and or food system participants, below this predetermined threshold (Figure 2.6).

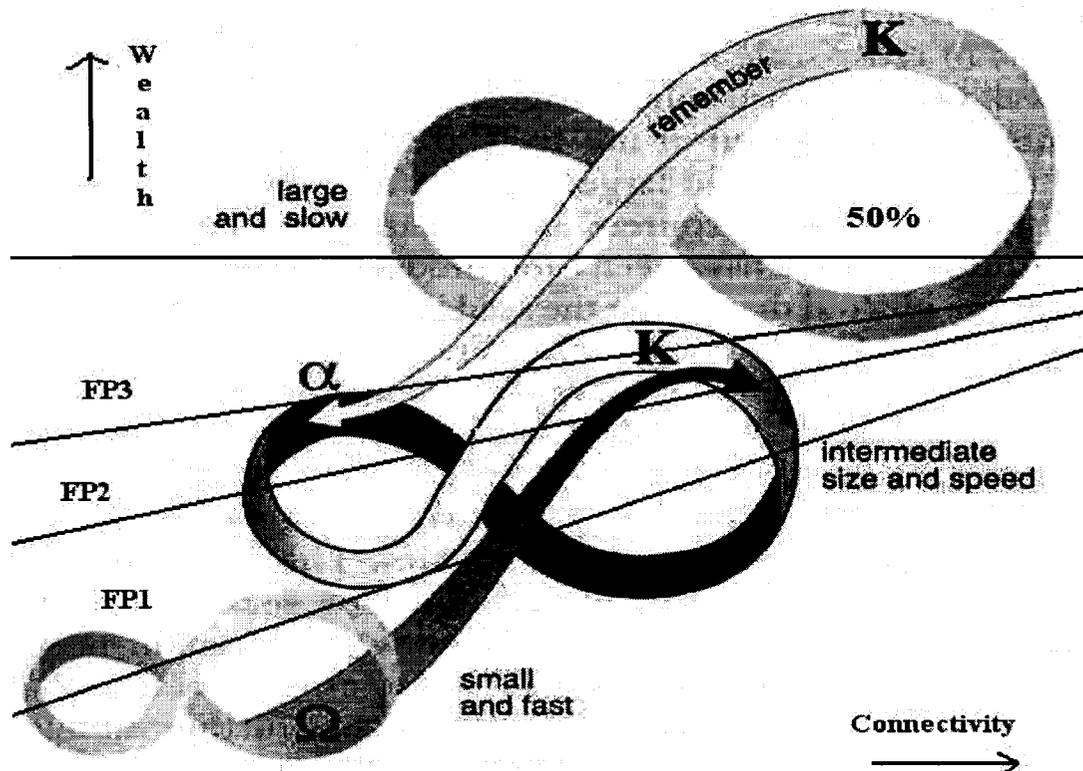


Figure 2.6 – Three adaptive cycles showing panarchical relationships along with a hypothetical 50% vulnerability to food insecurity threshold, and the three proposed food poverty thresholds with the food secure above the 50% line, the food insecure below either of the food poverty lines (FP1, FP2, FP3), and the vulnerable to food insecurity in between. Increasing wealth is on the Y-axis while increasing connectivity is on the X-axis. Edited from Gunderson and Holling 2002.

Along with the ‘50% food security — vulnerability to food insecurity’ threshold above, there are also three ‘vulnerability — food insecurity’ thresholds determined by food poverty lines (FP1, FP2, and FP3). Food poverty methodologies are used by a majority of developing countries including Belize (CSO 2004). It involves choosing a food basket that will provide a prescribed minimum level of dietary energy, estimating (1) the cost of the food basket, (2) the per capita income (or expenditure), and (3) the geographic and demographic distribution of the target population.

Table 2.4 – Differences between the Food Poor (Indigent) and the Poor.

Poor	The poverty line is one of the key factors in estimating the number of poor or non-poor persons. It is based on the minimum estimated cost of basic food and non-food items that a household requires to meet its basic needs. For example, the non-food cost may be estimated using the pattern of expenditure of the poorest 40% of the population. The cost of the food basket is then inflated by multiplying the reciprocal of the food share of the poorest 40%. Persons whose per-capita consumption falls below the poverty line are considered poor.
Indigent	Also called the food poor, income poor, or extreme poor. Measurements are based upon a food basket providing a minimum level of dietary energy (not basic foods as measured above for the poor). It excludes non-food items as well. Persons with income below this food poverty line are called the indigent, a sub-set of overall poverty.

Source: Adapted from CSO 2004.

Persons with income below the food poverty line are called the food poor, suffering from extreme poverty, a sub-set of overall poverty, and their proportion is a measure of food poverty incidence (adapted from David 2002). The food poor are referred to as the indigent as the food poor consider only the food aspect while the ‘general’ poor include non-food elements (Table 2.4).

The food poverty lines are thresholds which distinguish between the vulnerable to food insecurity and the food insecure. Figure 2.6 shows three possible thresholds taking on different angles and starting points as each measure is selected and defined. However, all food poverty thresholds are found below the 50% vulnerability to food insecurity threshold. Definitions for the three separate food poverty thresholds are:

- The true food poverty line (FP1). The most extreme expression of poverty which refers to the impossibility of obtaining a food basket needed for adequate nutrition, given the consumption patterns within a particular food system, using all available forms of wealth. The indigent can be determined using this threshold;
- An intermediate basic needs food wealth line (FP2). This is the food capabilities poverty line which refers to the failure to reach the level of expenditure needed to obtain a reference food basket plus the wealth expenditure needed for health, clothing, housing, transportation, education and other basic needs; and
- The assets food poverty line (FP3). This is the least impoverished food poverty line which addresses the inability to obtain the value of the reference food basket plus an estimate of non-food expenditure considered as necessary in general. The food poor can be determined using this threshold.

Figure 2.6 demonstrates that entire food systems, i.e. separate adaptive cycle representing a different food regime, may be vulnerable to food insecurity even food insecure.

Individuals, households, and communities, all part of the same food regime, may move in and out of both vulnerability and food insecurity levels, to varying degrees, as they

progress through the adaptive cycle phases. In which adaptive cycle they participate situates them in Figure 2.6. A larger wealthier, well connected and slower food system has greater chances of ensuring food security by maintaining functions and services through increased food system resilience than lower-level faster systems with reduced food system resilience characterised as less wealthy and connected. At the same moment in time, whole regimes themselves or adaptive cycles, each representative of a particular food system, or parts of those regimes or their components can be found within three groups: the food secure, those vulnerable to food insecurity, and the food insecure with thresholds between them. For instance, dissipative regimes, with weaker levels of wealth, connectivity and diversity, have the greatest probability of becoming food insecure if not already in a food insecure state as indicated in Figure 2.6.

Lastly, increasing stability in tenable food systems favours food security as reducing vulnerability is a prerequisite for achieving food security. Management strategies following the release phase of the adaptive cycle, if any, then serve to reduce time spent under increased vulnerability and food insecurity in efforts to reach previous threshold levels in a dissipative adaptive cycle while using the opportunity to raise food security levels above initial positions, elevating SSC, improving if possible, food system services and functionality. Here, food (in)security is an outcome measure relative to the food poverty threshold based on food availability, access, utilisation, and stability, e.g. based upon energy intake, also represented by a proxy measure using predefined food poverty lines or indigent lines, i.e. FP1 through FP3 in Figure 2.6.

2.4.3 Connectivity and Food Security

Resilience analysis and assessment differ from traditional approaches to impact analysis. Adapted from Clark et al. (2000) and Corell et al. (2001), typical impact assessments select a particular risk and seek to identify its consequences for a variety of social or ecosystem properties. Resilience assessments, in contrast, select a particular group or unit of concern, e.g. landless farmers or coastal communities, and seek to determine the risk of specific adverse outcomes for that group, and to identify a range of factors that may reduce response capacity and adaptation to stressors. Conventional impact analysis approaches are not well suited to the purposes of this thesis, primarily because resilience analysis looks at effects as caused by multiple often synergistic factors, while impact analysis looks for multiple effects of a single causal factor.

Changes from multiple, often synergistic external factors must be captured and internalised into the food system resilience framework for the adaptive cycle to respond to change. The approach increases the connectivity between factors within the overall framework. For instance, connectivity is developed when a food system is threatened by an externalised risk such as food safety concerns with consequent illnesses appearing such as diarrhoea. Subsequently, measures are developed to internalise the risk by training food handlers at stalls, instructing the population on washing hands, and increasing investments by institutions in programmes around food safety. Another example is the market risk faced by farmers and fishers. Access to markets is increasingly seen as an essential element in ensuring food security, however, the nature of those markets is changing, bringing about shifts in both levels and forms of participation as

new risks are brought about by difficulties in meeting higher food standards and productivity levels (Page and Slater 2003). Resilience bands will remain diminished until such standards and levels are internalised consequently increasing connectivity and the width of the resilience band to support larger SSC.

The degree of SSC change that occurs in multi-layered and spatially-structured systems, and in particular, whether such systems cross any key thresholds, becomes the focal response variable that best represents whether or not the systems are resilient to the changes brought about by increased connectivity (Cumming et al. 2005) as well as marginally deteriorating or abrupt loss of wealth (added). Connectivity favours food security development until, during the conservation stage in the adaptive cycle, any further increases amplify vulnerability and risk, accompanied by loss of wealth and ensuing food security degradation leading to release. Work on connective stability by Siljak (1978) from food webs to trade networks showed that indiscriminately increasing connectivity may increase productivity and even asymptotic stability, but reduces resilience to structural perturbations in the system, i.e. heightened vulnerability to risk. However, dissipative food system structures interconnected across scale remain stable relative to disruptions in connectivity (release), if they are self-contained and the interdependence between them is properly limited. For example, impacts from disruptions in connectivity such as tariffs on trade, for the export oriented food system and its dissipative structure will not affect the traditionally-led domestic food production dissipative structure and related adaptive cycles.

Lastly, connectivity reveals linkages across time as short-term actions may either prove costly or beneficial to longer-term resilience. Hence, not all resilience may be accounted for, what Rochlin (1997) called slack capacity, as some forms of wealth are not connected to response capacity, i.e. capacity that is unaffected by change. Conversely, exploiting all opportunities for mutual gain (Levin et al. 1998) may in fact reduce potential resilience by leaving no such slack. However, it may require a different kind of slack, capacity as yet unexplored, unvalued resources such as biodiversity, and the ability to learn (Lélé 1998). Lower-level dissipative structures will tend to maximise and exploit all of their accessible forms of wealth as they take action to avoid or minimize undesirable outcomes in efforts to reduce their probability of becoming vulnerable and food insecure. However, food system imperfections have limited their ability to cope with risk. This explains why such risk management strategies as informal wealth mechanisms exist within households, communities or social groups in many developing countries. However, such actions have short-term costs to increase longer-term resilience due to limited wealth. For example, households will attempt to satisfy consumption requirements by adapting to local conditions long before they resort to permanent out-migration; or households will change the composition of their diet, e.g. consuming more famine foods obtained by gathering, before they sell their productive assets (Watts 1983).

2.5 Chapter Inferences

The adaptive cycle provides a compromise in that it offers diagnostics of complex systems (Gunderson and Holling 2002, Holling 2001, Holling 2004) and can analyse the social, economic and ecological variables comprehensively. It can also help illuminate

vulnerability in socio-ecological systems (Holling 2004). An adaptive cycle's backloop is a critical time and presents opportunities for experiment and learning. It is when uncertainties arise and when resilience is tested and established (the release and reorganisation portions of Figure 2.1). During a back loop, unexpected interactions can occur among previously separate properties that can then nucleate an inherently novel and unexpected focus for future food security or insecurity in the next cycle. Using social and ecological systems described by Berkes et al. (2004), the essence of food security is defined by processes that evolved during a back loop. Fraser et al. (2005) concluded that adaptive cycles used to identify food system vulnerability, require clearer methods to assess wealth, diversity and connectivity while Anderies et al. (2006) contend resilience theory can be a very appropriate and helpful approach to structuring the study and management of social-ecological systems, *such as with food systems* (added). This chapter has attempted to summarize resilience-based concepts and to address how the resilience of social-ecological systems can be made operational in the case of food systems. This chapter has also provided emerging research views such as the resilience bands, and merging food system and food security theory to resilience theory.

This chapter has also offered an opportunity to further pursue the development and research of a more robust resilience analytical framework for the study of food security, methods, reviewed and appraised in Chapter 4, will demonstrate how they are less able to fully address neither longer-term food security nor vulnerability. Preliminary thinking indicates that food security accumulates and is concentrated under the conservation portion of the adaptive cycle (K phase). However, food system participants and agents at

the same focal scale are found everywhere around the adaptive cycle (both adaptive cycle back- and foreloops, expressing release and reorganisation phases, and growth and conservation phases respectively) always in motion, slowing down under conservation. However, not all SSC or focal states are equally accessible (Walker et al. 2006). Several adaptive cycles may coexist within similar SSC. In addition, distinctive adaptive cycles may coexist within the same space at different scales, SSC and dissipative states, such as within a district or country. Moreover, structures and processes are also linked across scales, based on the interactions between slow and broad structures and processes as well as those that are fast and small. These interactions are known as hierarchical confinement or panarchical relations. Lastly, the dynamics of a food system at a particular scale of interest, i.e. the focal state, cannot be understood without taking into account the dynamics and cross-scale influences of the processes from the adaptive cycles at scales above and below it, food systems sharing the same geographical boundaries in particular.

Food security thresholds cross the framework both starting nearest each other between the conservation and release portions once change occurs (i.e. following release, Figure 2.6) breaking away from each other with increasing wealth and decreasing connectivity. Diversity shifts the whole system upwards towards a higher-level dissipative state, a broader but slower state or adaptive cycle with an emphasis on a larger conservation phase with enhanced food security. The upper threshold distinguishes the food secure from the vulnerable while the bottom food poverty threshold divides the vulnerable from the food insecure on the aggregate. Once change has occurred, depending on the risk management strategies of food system participants or social groups, these participants

may in extreme cases quickly loop around the reorganisation and exploitation portions of the adaptive cycle while remaining relatively weakly vulnerable or always food secure (never passing below the threshold), while others may fall hard beyond the vulnerability and food insecurity thresholds looping very slowly around but insufficiently so as to never reach above either threshold, exiting during the reorganisation phase and establishing a novel self-organising adaptive cycle in a dissipative state. aim

Preferably, food system resilience seeks to ensure food security for all at all times by broadening the length of time and height of the conservation phase of the adaptive cycle above the vulnerability threshold. In this way food system meets its sustainability goals, i.e. desired conditions and processes, set out in the introduction.

Chapter 3 - Situating Food Security and Food Systems in Resilience

A common challenge found in the literature has been in achieving consensus around the meaning of resilience and how to render resilience operational and quantifiable.

Carpenter et al. (2001) discuss the challenges of the past 30 years in attempting to put resilience into practice. A review of the literature by Schoon (2005) found 21 different meanings for resilience; however, no empirical studies that measure food system resilience have been found. As demonstrated in previous chapters, adaptive cycles are closely coupled to: (1) ecological, (2) social, and (3) economic wealth layers as well as to (4) food security. Before this chapter captures this four-dimensional view of food system resilience, concepts of food security and food systems are first reviewed and appraised followed by a range of causal factors to highlight the complexity of food systems. It will bring in vulnerability concepts and notions of how food systems react to change. The chapter also stresses the importance of changes in labour productivity. It will also show how the same geographic change affects the capacity to respond to vulnerability differently, and how vulnerability to food insecurity is differentiated by food security thresholds.

The chapter also pioneers the concept of food provision systems (FPS). It underscores how food systems are ill-structured for ensuring food security as the FPS participants have many competing purposes and priorities, while food system participants exercise leverage over food system sustainability, restructuring, transforming or destructing FPS. The chapter further emphasises how ecological, social and economic wealth factors,

significant driving forces of food systems, affect the disposition of resources used in the production, exchange, distribution, and consumption of food. The chapter also makes the case both for identifying cyclical and iterative processes and feedback loops, characteristic of resilience theory, and for the necessity to conceptualise distinct FPS at multi-layered scales each distinguished by their adaptive cycle and panarchical relationships across scales. The chapter ends with the development of a four-dimensional view of food system resilience coupled with their respective food security pillar.

3.1 Food Security

3.1.1 Definition and Concepts of Food Security

Over time, the concept of food security has evolved in a number of ways, from food surplus disposal, food for development, food assistance, and the freedom from hunger and malnutrition, among others. In an exhaustive review of the literature on household food security, 194 different studies were listed on the concept and definition of food security, and 172 studies on indicators of food security (Maxwell 1995). A review that updates this literature (Clay 1997) provides an additional 72 references. Smith et al. (1992) and Hoddinott (1999) counted up to as many as 200 different definitions and approximately 450 indicators of food security.

Food security has historically been referred to the overall regional, national, or even global food supply, as well as shortfalls in supply and food availability (Riely et al 1995). But, with increased observations of insufficient food intake and utilisation by certain groups, despite overall adequacy of the food supply (IFPRI 2005), the term has more

recently been applied to the community, local, household or individual level (Foster 1992). Furthermore, the term has been broadened beyond notions of food supply to include elements of access (determined by food entitlements, Sen 1981), vulnerability (Watts and Bohle 1993), sustainability (Chambers 1989), social acceptability (Radimer et al. 1990, Kendall et al. 1995), and more recently stability (FAO 2005). Only a few studies have broadened the notion of food security to include elements of resilience (Fraser 2003, Fraser et al. 2005).

The concept of food security has had several mutations and gone beyond the food dimension, highlighting linkages to non-food and social components, such as access to health services and a healthy environment, adequate care of children and women, as well as education, to achieve nutritional well-being (Jonsson 1993). According to a currently accepted definition agreed upon at the 1996 World Food Summit (FAO 1996), food security is achieved when it is ensured that all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food which meets their dietary needs and food preferences for an active and healthy life. Conversely, food insecurity exists whenever the availability of nutritionally adequate and safe foods, or the ability to acquire or use acceptable foods in socially acceptable ways, are limited, uncertain, or lost (Anderson 1990). In most populations and food systems at any given time, a proportion of people experience food security, degrees of vulnerability to food insecurity, or food insecurity. Such food insecurity may be experienced as not having sufficient amounts of nutritious food or consuming a poor quality diet; and feelings of stress and anxiety either about acquiring food or diet quality (Hamelin et al. 2002).

In sum, food security is a multi-dimensional development issue that involves cross-sectoral integrated components. It is not only dependent on agricultural production, or food imports, exchanges and donations, but also on off-farm and on-farm employment opportunities, intra-household decision-making, health care access and caring practices for example. Food security is about equitable access to markets, distribution of resources, within households, among individuals, across communities. Food security is also about viable options and opportunities to take action, make decisions, or boost enfranchisement (Appadurai 1984), i.e. the ability to participate in decisions about entitlements, and to enforce rights to food and livelihoods.

3.1.2 The Four Common Food Security Pillars

Both physical and temporal factors influence food security. The physical determinant is the food flow along the food system cycle (Figure 1.1): availability, accessibility, and utilisation. The temporal determinant of food security refers to stability, which affects all three physical elements. Together, they represent the four categorical aspects or pillars of food security.

Food availability is derived from agricultural production, e.g. from cash crops, livestock, fishing and forestry as well as food cultivation, ideally by means of a sustainable use of natural resources. The availability of food is a function of domestic production enhanced by net food trade, i.e. commercial imports and food aid minus exports, processing and losses. It is made up of supply, e.g. agricultural output, fisheries, imports, aid, gifts and

exchanges; and harvesting, processing, storage and distribution. Food availability is necessary to ensure food security but not a sufficient condition for attaining food access.

Food access refers to the ability to secure food, e.g. from the market, and to means of production. Purchasing power is critical to food access and this varies in relation to market integration, price policies, and temporal market conditions. By way of purchasing power and affordability in the market, or own production (with access to inputs, land, credit, technology), food access is necessary for achieving food security but not a sufficient condition for realising food utilisation.

Food utilisation refers to food preference influenced by culture, food safety, food quality, health status and patterns of consumption. This requires a healthy resource base such as safe water and sanitation. However, food utilisation may not fully lead to nutrition security, e.g. inadequate energy, protein and micronutrient intake. As a result, the food insecure are malnourished at one extreme and suffering from nutrition-related non-communicable diseases at the other, e.g. obesity, diabetes.

Stability is the fourth and most recent food security pillar. This pillar overreaches the first three food security pillars, and can either disrupt or facilitate their attainment, not only food availability or the food supply. As stability is a more recent concept to food security, a more in-depth examination is given below than for the previous three food security pillars.

FAO (2001) has established that greater occurrences in food system disruptions lead to lower progress in reducing the number of food insecure. These disruptions gave way to the recent conceptual introduction of the need for stability to address temporal aspects of food security. Numerous factors can steady, disrupt or bolster food security directly, e.g. weather conditions, incomes, nutritional adequacy, food affordability, and effective food policies. Also affecting the stability of supply, food access and utilisation obliquely are non-food related changes that bolster or curb food security, i.e. peace, forced human migration, political strife, trade agreements, macro-economic devaluations, and natural hazards.

With greater economic, social and ecological wealth, present in the conservation phase of the adaptive cycle, FPS participants are less vulnerable to food insecurity as many consumers have a substantial buffer of non-food expenditures to rely on, i.e. a larger band of tolerance and absorbing SSC, even if food prices rise sharply (Dowler 2003, Timmer et al. 1983). Without this food system resilience sources or buffers, consumers in poor countries are exposed to routine food insecurity, and vulnerability to acute changes that set off such insecurity (Anderson and Roumasset 1996). Wars, civil strife, hurricanes, and floods, for example, can disrupt the smooth functioning of food systems. However, some food systems might show surprisingly strong resilience in times of crises. For instance, it was assumed that conflict merely disrupts markets, nevertheless it is acknowledged that conflict has a much more complex impact on production, subsistence and markets, whereby some agricultural markets remain surprisingly resilient and thrive (Kanbur 2001, Maletta 2002).

Economic growth that reaches the poor is often viewed as an important aspect of a food security strategy (World Bank 1993). In the language of Dreze and Sen (1989), such economic growth provides “growth-mediated security.” For example, the stabilisation of food prices in Asia ensured that short-run fluctuations and shocks did not further increase vulnerability to inadequate food intake against their low income threshold based on food access (Timmer 1993). For food security in this region, the stabilisation of domestic rice prices was feasible in the context of an expanding role for an efficient private marketing sector (Timmer 2000). In addition, improvements in agricultural productivity that are stimulated by government investment in rural infrastructure, agricultural research/extension, irrigation, and price incentives, contribute directly to economic growth, stability and food system resilience (Timmer 1992, 1995). Greater food system stability contributes to faster economic growth by lengthening the investment horizon and reducing political instability (Ramey and Ramey 1995, Dawe 1996). Enhanced food system stability also contributes to equity and poverty alleviation by reducing food system vulnerability to shocks in food prices or food availability. Lastly, Williamson (1993) and Birdsall et al. (1995) found greater equity also stimulated investment in social wealth, speeding up economic growth.

One important outcome of such a growth strategy is the achievement of food security: this occurs when economic growth has raised the poor above a meaningful food insecurity threshold, and when food system stabilisation prevents exogenous shocks from threatening their food security. To achieve food system resilience under this approach, two conditions are required: (1) that food security is sustained by the productivity of the

food system providers themselves, and (2) that this food security continues to depend on the public sector to maintain a stable macro-economic environment as the precursor to that productivity (adapted from Timmer 2000).

Sizing up the four pillars, food security is a broad and complex concept that is determined by agro-physical, socio-economic, and biological factors (Campbell 1991, von Braun et al. 1992). By implication, the food insecure have lost, or are at risk of losing, availability and access to food, or the ability to use it over time.

3.1.3 Cross-cutting Issues in Food Security

Many dimensions, causes and outcomes of food insecurity exist¹. Of these, this section will review seven food security dimensions relevant to this research: both a (1) spatial and (2) a temporal dimension, along with four other less recognised dimensions, i.e. (3) short-term food crises, (4) severity, (5) poverty, and (6) gender. Lastly, special attention is given to (7) malnutrition, a well-researched conventional outcome, and regularly reported form of food insecurity.

The spatial dimension suggests that food security can occur at different human organisational levels. The four food security pillars are relevant to all food system scales,

¹ Other causes debatably as important at different scales include: factors affecting income, e.g. high commodity prices or fluctuations for net-buyers and so vulnerability to market fluctuations; variability of, and poor diversification of sources in, or distribution of income; low real wages; poor or unstable sources and distribution of income; lack of off-farm employment; inadequate food, marketing and macro-policies; overvalued exchange rates; transport constraints; higher average annual rate of growth of population over that of agriculture; low productivity; large variability in production; financial unsustainability and unsuccessful use of price stabilisation mechanisms (e.g. buffer stocks, or misuse of tariffs and poorly targeted subsidies); corruption; unequal intra-allocation of cash and other resources in the household; a frail rural or urban infrastructure; lack of extension; lack of nutritional education (e.g. poor weaning practices, low adoption of fortified foods); and imperfect access to safe potable water and inadequate sanitation.

from the individual and the household, i.e. the micro-scale; to the community (village, sub-district, city, district, provincial) or meso-scale; and the national, regional and global level or macro-scale. The relative significance of determinant food security factors changes with the level of self-organisation at each focal scale. At higher scales, the overall ecological, social and economical conditions become more prominent. Given the diverse nature of food security, and the different food system scales in which it interacts, the relevance of food system resilience at each scale and the interaction and relationships between these scales, i.e. adaptive cycles, is vital to ensuring future food security.

Food system stability refers to the temporal dimension of food security, whether food insecurity and vulnerability are chronic or intermittent. Food security degradation may either be transitory, arising from flooding, drought or political unrest, or of a more long-term nature (Maxwell and Frankenberger 1992). In the short-term, food insecurity severity is most salient during emergencies over the duration of the crisis (Devereux 2006). For instance, it is more critical to know the magnitude of the food gap, i.e. reference to a food security threshold, than for how long the affected population has faced this food gap. In practice, these two dimensions of food security, magnitude and duration, are usually considered jointly. For example, Devereux (2006) illustrates how a community whose food security status is gradually eroding over time will not receive humanitarian assistance when average food consumption dips below a cut-off threshold. Similarly, a food secure population whose food consumption falls suddenly is more likely to receive much humanitarian attention. The author suggests the simplest way of thinking

about different intensities of food insecurity is in terms of food utilisation, or levels of food intake.

In a food crisis, more appropriate food aid targeting and rapid mobilisation of emergency food reserves can help alleviate transitory food insecurity from the release phase to the reorganisation phase along a food system's adaptive cycle as greater food availability is viewed as a form of increased wealth. In terms of food system resilience, it is overcoming poverty driven chronic food insecurity founded upon a fundamental lack of capacity, or economic wealth, that is key for self-organisation and innovation along the adaptive cycle phases, or an entire shift into a new adaptive cycle as the food insecure attempt to extricate themselves from food insecure conditions. Often they have few options available for addressing change, and are left with labour as their only asset, often devalued (Christoplos et al. 2004), as they cannot rebuild their wealth, either social, ecological nor economic, leading to inter-generational incapacity of ensuring food security (Fogel 1994, Smith et al. 2003), contrary to the sustainability goals of the food system.

Food security is inextricably linked to poverty, notably in rural areas that have been exacerbated by the globalisation of agricultural commodities, and ensuing pressure on commodity prices. Whilst reducing poverty would afford individuals more economic wealth for purchasing either food directly or agricultural technology, increased food security would enable surplus to be sold at local markets, thus generating an income, reducing poverty and ensuring greater land, resource stewardship and ecological wealth

(Webb 2002). Globally, projected world increases in food availability will be sufficient to meet most needs only at an aggregate level as long as prices move in the expected directions and no major unexpected shifts in dietary demand occur (IFPRI 2005).

However, the food produced in coming decades will still not suffice to reduce under-nutrition unless poverty has been reduced sufficiently to enhance purchasing power among the poor and/or food is redistributed across food systems at all scales.

Two important poverty-related critiques of high-input/output agriculture often characteristic of export-oriented food systems are relevant here. On the one hand, high-cost inputs are most available in already higher-potential food systems. That is, markets, irrigation structures, electricity and credit systems are often in place, and information and wealth flows are greatest where agriculture is already productive and where population density is sufficient to meet labour demand. This means that lesser potential agro-ecological food systems have been less likely to gain from high-technology developments in agriculture (Pretty 1998, Webb 2002). Such areas include mountain highlands, semi-arid zones and more remote tropical forest margins. On the other hand, even in higher potential regions that are home to Green Revolution technologies, poor households were not guaranteed access to the new technologies due to land, capital or other wealth constraints for some (Evenson and Gollin 2003, Mellor 1976), as their lower-level adaptive cycles could not employ panarchical relationships to revolt and self-organise at higher-level SSC. As a result, the productivity gains promised by high-input techniques are not uniformly shared among producers, leaving out large numbers of food system participants whose food requirements are not met by the food surplus areas surrounding

them, an illustration of food insecurity lead by inequality in patriarchal relationships among adaptive cycles.

A less recognised dimension of food security is gender (IFPRI 1999). Gender relates to the socially assigned roles and behaviours of men and women. Gender is the social meaning of biological sex differences. It affects work, decision-making and political power, and the enjoyment of rights and entitlements within the family as well as public life (DAW 1999). A women's status is linked to food system resilience. Paramount to food system resilience, it affects the distribution of resources and wealth: identifying an individual's differential access to economic, social and ecological wealth and benefits is the fundamental feature of gender analysis, and ensuring equitable intra-household access and distribution will enhance food security (Quisumbing et al. 1995), and consequently food system resilience through improved food utilisation. This study demonstrated how women play an important role as producers of food, as managers of ecological wealth, e.g. natural resources, of economic wealth, e.g. income generation, and of social wealth, e.g. as providers of care for their families. However, results showed women continue to have limited access to wealth, in terms of land, education, credit, information, technology and decision making bodies. While both men and women are income earners and agricultural producers, women also process and prepare most of the food, and use their income for their children's benefit (Carr 1991, Thomas 1997). Women also provide the majority of care for their families, take their children to health services, and ensure a healthy environment, the very components of good nutrition and food utilisation (Levin et al. 1999). In conditions of gender inequality, women and girls are more poorly

nourished throughout the life cycle, show higher rates of mortality, have less access to health care, and are subject to greater household food insecurity (UN SCN 2004).

Quisumbing et al. (1995) emphasised the strong relevance of intra-household allocation as results showed that improvements in household welfare depend not only on the level of household income, but also on who earns that income. Women, relative to men, tend to spend their income over-proportionately on food for their families. Women's incomes are more strongly associated with improvements in the health and nutritional status of their children than men's incomes. Lastly, raising women's status and improving intra-household allocation and gender equality is a powerful force for improving not only food system resilience but current food security, health, longevity, mental and physical capacity, and productivity across generations (Smith et al. 2003).

Understanding the relationships between the various dimensions, one can infer that the causes of food insecurity are intricate and multifaceted. Some causes have arguably greater impact, e.g. civil strife, war, and poverty can be considered as leading causes, followed by macro-economic impacts and global environmental change. For instance, basic causal factors can vary: von Braun et al. (1999) define them as (1) the economy, policies, social discrimination and conflicts, (2) resource endowments, climate and disaster events, (3) poverty and food availability, and (4) population growth. Kracht (1999) describes the basic food security and nutrition problems as due to:

- Famines and starvation caused by civil strife or weather related crop failures, although war and civil strife just as natural hazards are the main source of famine

globally. In 2003–2004, almost a third of all food emergencies (35 in all) were caused by present or past conflicts; half of them (18) were caused by natural shocks; and three were caused by economic shocks or refugee crises (FAO 2005);

- Chronic and transitory under-nutrition due to inadequate access to food by large population groups;
- Protein-energy malnutrition especially among mothers and young children, caused by a combination of educational, sanitary, health and food quality and quantity factors; and
- Micronutrient deficiency disorders with health and development implications (e.g. iron, zinc, vitamin A, and iodine).

Malnutrition is a direct result of inadequate dietary intake and disease, which, in turn, are the result of insufficient household food security, inadequate maternal and childcare, insufficient health services, and an unhealthy environment (Gillespie, Mason, and Martorell 1996). Similarly, Abosedo and McGuire (1991) found that the main sources of malnutrition are inadequate food intake, excessive disease, maternal malnutrition, and deleterious food and health behaviour. Effective food utilisation depends on knowledge within the household of food storage and processing techniques, basic principles of diet and nutrition, and proper childcare and illness management. Recent data indicate that while there are sufficient amounts of food available worldwide, malnutrition continues to be highly problematic and, in some regions, on the rise (IFPRI 2005).

Greater differences in malnutrition are found in the nutritional status of household members of low-income households, whilst the differences tend to vanish with high-income levels or greater economic wealth (Kanbur and Haddad 1994). Further evidence shows that increased income does not necessarily translate into improved nutrition (Marek 1992, Pelletier et al. 1995). In their research, von Braun and Pandya-Lorch (1991) found that food-deficient households tend to be larger, to have a higher number of dependants, and a younger age-composition. In the long-term, improved nutrition, as an element of human welfare, may contribute to slowing population growth. There are strong positive relationships between improved nutrition and economic development, and between economic development and a population's transition from a high birth rate and low life expectancy, to longer life expectancy, and thereafter, lower birth rates (Fogel 1994). As improved nutrition fosters economic growth in part, it also alleviates population growth and pressures on ecological wealth. Hence, improvements in food utilisation, e.g. nutrition and health, contribute significantly to economic and ecological wealth. Bonnard (2001) found that nutrition, as the engine of labour productivity, is as important as technical inputs such as seeds, fertilisers, and credit. It can be said that nutrition and the resource base used for agriculture form a synergistic cycle, whereby each supports and advances the other in a cyclical manner similar to food system cycles and resilience theory.

Food utilisation is often represented by daily dietary energy intake. While a country may appear to have sufficient food availability to meet its population's daily per capita energy requirement (FAO 2006), the health status of its population suggests that they may not be

able to use the nutrients in the food they consume (Abosedo and McGuire 1991, Gillespie et al. 1996). It is important to note that these aggregate daily figures tell only part of the story as they mask variations at the individual, household, community and lower scales. While a household may be food secure, individual household members may suffer from food insecurity (IFPRI 1999). As with intra-household allocation and distribution of resources, household decision-making contributes significantly to individuals' abilities to access the food (and other resources) they need to grow and develop.

To summarise these cross-cutting issues, food insecurity has significant consequences on the nutritional status of food system participants and the links between food system resilience and nutritional status are intimate. Forms of malnutrition vary in nutrient deficiency, in gender inequality of food utilisation, in spatial coverage and distribution, and they may be chronic or transitory (temporal dimension), and vary in severity. Malnutrition significantly impedes overall food system resilience as reducing malnutrition becomes a cornerstone in poverty reduction and wealth development strategies.

3.1.4 Vulnerability to Food Insecurity

'Vulnerability to food insecurity' is the susceptibility to future harm from the outcome of food system changes. It is the space within food system resilience theory between the 50% food insecurity probability threshold above, and a pre-defined food poverty threshold below. Frameworks for integrating longer-term vulnerability into food security analysis, however, are largely not well-developed (Haddad and Frankenberger 2003,

Løvendal and Knowles 2005, Webb and Rogers 2003) or have been poorly incorporated into food security assessments, despite efforts by the Intergovernmental Panel on Climate Change to address vulnerability (IPCC 2001).

Vulnerability has been described in various ways in the literature. Watts and Bohle (1993) define vulnerability as a multi-layered and multi-dimensional social space defined by determinate political, economic and institutional capabilities of people in specific places² and specific times. Other studies distinguish vulnerability between its biophysical, economic and social aspects (Adger 1999, Dow 1992, Fraser 2003, Liverman 1994 and 2001, Mustafa 1998, and Reilly 1996) similar to the three forms of wealth, economic, social and ecological, in food system resilience theory. The perception of vulnerability differs across disciplines (Alwang et al. 2001, Wisner 2005) and is often seen as structurally unrelated to change (Løvendal and Knowles 2005). Food system vulnerabilities threaten both temporal and spatial food security dimensions. Vulnerability and food security are not at opposite ends of a spectrum, rather, food insecurity increases along a vulnerability spectrum, with increasing wealth degradation. Conversely, it is only recently that entire societies, as opposed to only certain privileged members of food systems have been able to escape from the constant threat of long-term chronic food insecurity (Fogel 1991). In areas where threats remain, understanding the factors that cause widespread vulnerability to food insecurity, and the mechanisms available to prevent and alleviate its impact, i.e. food system resilience, have remained important intellectual challenges (Sen 1981, Ravallion 1987 and 1997, Dreze and Sen 1989).

² The specific place examined in this thesis focuses on Belize, at two scales, one national and another with special attention given to a rural district as a majority of the food insecure and poor live in rural areas and work in the agricultural sector.

While the overall impact of global change on food security may be small, regional vulnerabilities to food deficits may increase, due to problems of distributing and marketing food to specific regions and groups of people (Rosensweig and Hillel 1995). For instance, an individual's poor health status, age and knowledge can increase vulnerability to natural hazards, as shown in studies on severe food insecurity (Downing 1991, Downing et al. 1995, Downing and Bakker 2000, Watts and Bohle 1993). In developing a concept to capture the extent to which environmental, political and economic change influence the capacity of food system participants to respond to various types of natural and socio-economic shocks within the same geographical space, O'Brien and Leichenko (2001) found there was a possibility of reduced vulnerability for some, but increased vulnerability for others. Further studies demonstrate that consequence from change, and the extent of associated human harm and system disruption, occurred unevenly both across regions and for different levels of development, social groups and generations, i.e. different adaptive cycles (Blaikie et al. 1994, Burton et al. 1993, Claussen and McNeilly 1998, Liverman 1990, Low and Gleeson 1998). Vulnerability can be summarised as comprising internal characteristics of a group or region, and external processes contributing to differential exposure, relative to a given hazard; and varying in scale (Kasperson et al. 2001). Impacts from change depend not only on the extent and pattern of the change, but on the on-going processes, and existing factors, contributing to food system resilience or capacity of particular food system participant groups or regions to be harmed.

The acknowledgement that neither a rapid-onset crisis, like a hurricane, nor chronic food insecurity, is experienced as a single, discrete and uniform event by all those affected (Webb and Rogers 2003, Wisner et al. 2004) has led to recognition of the importance of understanding agents of change and corresponding resilience and vulnerability (Christoplos et al. 2004). As some food system participants perpetually express some state of food insecurity, vulnerability to food insecurity, and food security, all three groups, however, are continually exposed to and buffeted by change such as weather variability, poor agronomic conditions, unemployment, disease or the precarious location of farms, and households in areas prone to natural hazards (OECD 2004). Should such change factors occur, they can lead to immediate short-term hardships followed by longer-term consequences. A food system's very exposure to such change offers difficult choices for supply-side providers. For example, does a farming household choose lower-yielding but less-variable seed variety, or a higher-yielding but riskier seed variety? In fact, the vulnerable and food insecure are able to manage many forms of risk and uncertainties through wealth allocation, formal and informal insurance, and/or by smoothing consumption (Alderman and Paxson 1992, Morduch 1994, Siegel and Alwang 1999). Given such possibilities in the latter parts of food systems regarding food utilisation, a focus on consumption variability will understate the overall risk (Morduch 1994) across all food security pillars. Such a focus on food utilisation may lead analysts to ignore the adverse consequences of vulnerability to food insecurity management strategies for permanent income or long-term improvements in well-being due to the degradation of household wealth and entitlements at other levels (Siegel and Alwang

1999). Collier and Hoeffler (2000) and Berdal and Malone (2000) found that inequitable access to wealth increased food system vulnerability.

Defining an area or population as vulnerable is not a prediction of negative consequences from change; it is an indication that across the range of possible changes, there are some outcomes that would lead to relatively more serious consequences for particular food systems. Demographic and health considerations among food system groups represent an area of specific concern in relation to a number of potential hazards. Population growth in marginal areas, e.g. dry lands, coasts, or degraded areas, may expose more people to additional stressors. When evaluating human vulnerability to food insecurity, age and place should also be taken into account (Hewitt and Burton 1971, Kaspersen et al. 2001). In a natural disaster for example, among the most vulnerable groups of people are the young children, pregnant and lactating women, the elderly and the disabled. Empirical vulnerability analysis through Food Insecurity and Vulnerability Information and Mapping Systems (FIVIMS) indicate geographic areas where vulnerable and food-insecure people are most likely to be found (Table 3.1, FAO 1999). Relevant to food system resilience theory, each of these groups of peoples and geographic areas follow distinct adaptive cycles.

Table 3.1 – Vulnerable people grouped by geographic area. Relevant to food system resilience theory, each of these groups and areas follow distinct adaptive cycles.

<p>Victims of conflict</p> <ul style="list-style-type: none"> • Internally displaced people • Refugees • Landless returnees • Landmine disabled • War invalids • War widows and orphans <p>Migrant workers and their families</p> <ul style="list-style-type: none"> • Migrant herders tending herds of others • Migrant laborers seeking seasonal work • Female-headed households left behind by migrant male laborers <p>Marginal populations in urban areas</p> <ul style="list-style-type: none"> • School dropouts • Unemployed • Rickshaw and motorcycle taxi drivers • Recently arrived migrants • People living in slums in urban periphery • Dockworkers and porters • Construction workers • Workers in the informal sector • Homeless people • Orphans • Street children • People living alone on small fixed incomes or without support (elderly, pensioners, widows and widowers, divorcees, invalids, handicapped people) • Beggars 	<p>People belonging to at-risk social groups</p> <ul style="list-style-type: none"> • Indigenous people • Ethnic minorities • Illiterate households <p>Some or all members of low-income households within vulnerable livelihood systems</p> <ul style="list-style-type: none"> • Subsistence or small scale farmers • Female-headed farming households • Landless peasants • Agricultural laborers • Fishers • Nomadic pastoralists • Sedentary herders, small-scale livestock producers and agro-pastoralists • Forest dwellers • Peri-urban small-scale agricultural producers and market gardeners • Day or contract laborers <p>Dependent people living alone or in low-income households with large family size</p> <ul style="list-style-type: none"> • Elderly • Women of childbearing age, especially pregnant and nursing mothers • Children under five years old, especially infants • Disabled and ill
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Source: FAO 1999

3.2 Food Systems

3.2.1 The Concept of Food Provision Systems

As the main means of supporting human life, food systems deserve attention. Food production, processing, distribution and marketing are estimated to account for over half of all work done in the world today (Grigg 1995). Systems are a means of conceptualising the relationships among different forces acting upon flows between

factors. The links which food has to many aspects of human welfare, livelihoods and lifestyles mean that food is in a pivotal position to influence the direction of social, economic and cultural theory (Atkins and Gasconi 1997) as well as the supply, transfer, selection and preparation of food become items of major concern to human health and well-being. While compiling popular accounts of food systems, Tansey and Worsley (1995) term food systems to mean any aspect of the production, marketing, processing, manufacturing, transport, wholesale, retail or consumption. Consequently, it has been widely accepted that to understand any one aspect of food, it is necessary to follow food provision from the producer to the consumer which has more recently been portrayed as land to lip (Fine 2002), plough to plate, and fin to fork. Food systems are thus composed of sequential processes: from production, through exchange, and distribution, to consumption and waste; and non-linear components such as actors, agents, inputs, demand, policies and regulations who drive these sequential processes. Both processes and non-linear components are part of a food provision system (FPS). FPS are made up of providers at each process of said systems: producers are provided with inputs to provide food for own consumption and for transfer informally or through the market at which point, traders, wholesalers and retailers provide, transport, distribute and exchange food to consumers who provide, select and prepare food for own consumption and their families, who in turn, provide information, signals, and feedback along the system regarding their choices in provision, while governments have the responsibility to provide regulations and monitor the provision of food at the various levels of the systems including waste and recycling. FPS can refer to a highly integrated system that includes everything from farm input suppliers to retail outlets, from farmers to consumers. FPS

pursue the identification of system elements and the inter-relationships between them. In the singular, it reflects the domination of a single global or over-arching system; in the plural, it reflects the systems at all lower scales, though many local food systems are disappearing (Pretty 1995). In sum, FPS can be defined as a chain of activities connecting food production, processing, distribution, consumption, and waste management, as well as all the associated regulatory institutions and activities, and how consumers socialise around food, to meet the minimum daily nutritional requirements in support of a balanced diet in quality and amount.

Malassis (1973, 1975) is considered to have pioneered theories of food system dynamics while Tansey and Worsley (1995) compiled some recent popular accounts of the food system (early to mid 90s). It is argued that systems analysis is a means of conceptualising the relationships between adaptive cycles, forces acting upon flows between FPS components. Thus central to food system resilience are the linkages amongst these aspects or panarchical relationships. For instance, Fine et al. (1996) demonstrated that reconstructing systems of provision for individual commodities ran the risk of neglecting the links between systems. FPS studies require an approach which takes the analysis beyond the farm gate to consider financial institutions, food processors and retailers, along with trade and transport, and intervention by the state (Fine 1994). FPS are still largely dependent upon production conditions that are influenced by seed quality, soil, light, heat and water, and also upon the perishable foods, requiring food security surveillance at all steps along FPS cycles. The analysis of systems of provision helps trace the FPS cycle by grasping the contingent combinations of factors that bear in

economic, social, cultural, political, technological arenas (Fine et al. 1996). Atkins and Bowler (2001) argue that patterns of FPS evolution are fundamental to these contingencies, with the result that historical geographies of FPS must be considered when pursuing FPS analysis. Therefore, the subsequent empirical work in this thesis will assess Belize's historical geographies to reveal the origin of the country's commodity export-oriented economy, starting with timber centuries past, to a focus on particular agricultural commodities today, to demonstrate how this trend explains in large part current food insecurity levels seen in Belize.

3.2.2. Stakes in Food Provision Systems Resilience

Cannon (2002) argues that food production is only one of the purposes of agriculture, and there are many stakeholders whose interest and power intervene with a greater chance of achieving priority than addressing the needs aforementioned. He argues that the allocation of productive resources throughout FPS, are increasingly a result of processes that are not based on nutritional need, as argued and supported in this thesis, but on variations in wealth and connectivity. The wealth factor, and hence power and entitlements, affect the disposition of resources used in production, exchange, distribution, and consumption, along FPS adaptive cycles.

As Fine (2002) states, the new rural sociology has acknowledged how absentee landlords, banks, wholesalers, retailers, property and labour markets, governments, international organisations and, ultimately, consumers, exercise leverage over rural sustainability, restructuring, transformation or destruction of FPS. FPS resilience captures this leverage

as a dynamic component in terms of connectivity influencing both the adaptive cycles phases and panarchical relationships. Illustrative of such panarchical relationships and hierarchical confinement between two sets of adaptive cycles, smaller dissipative FPS are vulnerable to the pressures from higher scales that come from multinational businesses, capital and aggressive food policies (Atkins and Gasconi 1997) as supported by a productionist era or paradigm established since the end of World War II (Lang and Heasman.2004). The authors demonstrate how often large-scale powerful stakeholders attempt and often succeed in ways that benefit them and their adaptive cycle connectivity over and above the needs to secure the food system or dealing with hunger. With regard to food, focusing on a few key commodities such as grains, sugar and beef, similar to nested adaptive cycles in rigidity traps and pathological states, Fordist agriculture was perceived to have been widespread globally, with common technologies being deployed for mass production of uniform commodities for multinational traders serving homogenised consumers and food regimes (Friedmann 1993, McMichael 1994).

Demand, purchasing power and economic wealth are significant driving forces of FPS. This is especially significant among the population that does not need, or is unable, to grow its own food, and is entirely provisioned through food purchases from cash income. As income increases, consumers spend relatively less income on food, and more on perceived superior foods, non-nutritional foods and non-agricultural foodstuff (Timmer et al. 1983). Hence, there is a shift in consumption patterns and tastes that accompany rising incomes. However, households situated in smaller dissipative FPS are regularly the unit of production as well as consumption (Moock 1986). They are starting points that are at

once dispersed, diverse and complicated (Chambers 1993). Several consumption patterns may be found within a typical household: with parents, children, grandparents, aunts, uncles and distant relatives. Frequently, the FPS are characterised by their diversity and dynamism. A majority of the world's population live in such spaces and units (Pretty 1995). They generally produce a high proportion of their subsistence requirements while the majority of such production is usually for subsistence purposes, rather than for cash income. And economic wealth is one factor of production that is frequently in short supply among the impoverished. Consequently, they have little power or entitlements within FPS (Sen 1981, Watts and Bohle 1993).

Pretty (1995) found that the process of modernisation has produced two distinct types of food supply (provision) systems, these are: (1) an integrated FPS, and (2) 'forgotten' FPS. The first type, mainly industrialised or developed through the Green Revolution, has been able to respond to high-input, high yielding systems, changing the local environments when necessary, types of agriculture endowed with FPS connectivity such as access to roads, international trade, modern inputs, irrigation, while destined mostly for urban and industrialised markets representing two-thirds of global FPS. However, by the mid 1990s, a full third of the world population, some 1.9 to 2.1 billion people were directly supported by forgotten FPS, the second FPS type as defined by Pretty (1995), systems located in drylands, wetlands, uplands, savannas, swamps, near-deserts, mountains, hills and forests, areas remote from and ill-connected to markets and infrastructure, based on fragile lands and often problematic soils. In fact, drylands worldwide cover approximately 40% of the earth's land surface and are a direct source of

livelihood for about one billion people, especially in developing countries (FAO 2003a). FAO results show nearly all drylands are at risk of land degradation, i.e. loss of ecological wealth, as a result of climate change, increasing human population, land over-use and poverty. This represents a threat to the food security and survival of FPS participants living in these areas as well as to the conservation of the biomass and biodiversity, and consequently the FPS functions.

Hence, a majority of food providers across the globe are vertically and horizontally integrated within various levels of FPS while others, mostly providers applying forgotten FPS, are disconnected from markets and located on marginal lands. However, both groups are providers and FPS participants in their respective sets of adaptive cycles, integrated and connected or not into larger-scale higher-level FPS. They adapt to influence FPS forces, factors and relationships which drive both SSC and the flows of food provision processes and sustainability. Globalisation is mostly supported by FPS participants in the largest and highest adaptive cycles. It is a project maintained by a discourse of inevitability, which precisely serves to hide the agencies and the interests that are producing it (Massey 1999). Despite globalisation, however, most food insecurity is still highly localised and locally generated (Paarlberg 2002). Moreover, additional FPS participants or processes such as food utilisation or agricultural trade policy, that are remote in space and time from the site of production, may further cause deficiencies or disruptions in local FPS (Cannon 2002). Conversely, local grassroots movements to remote international pressure may bear positive influences on reducing vulnerability and ensuring greater food security (Bates 1998, Haddad 2003).

In sum, FPSs are complex networks of activity and interaction that affect the production, consumption, appropriation, trading, and circulation of food. Involved are a sequence of physical events: namely, the incorporation of energy, labour, and raw materials into food and the circulation of foodstuffs in circuits up to the point of consumption, which are not static and immutable but constantly changing in response to ecological and socio-economical influences (Watts 1983). Such influences are potential sources of both maintenance or loss of FPS functions, which bear upon all four pillars of food security, and consequently, the four dimensions of FPS resilience.

3.3 The Four Dimensions of Food System Resilience

3.3.1 Introduction

Empirically, the measure of resilience remains a critical issue (Walker et al. 2006). Several authors have proposed proxies or surrogates for resilience of social-ecological systems (Allen et al. 2005, Bennett et al. 2005, Carpenter et al. 2005, Cumming et al. 2005, Kasperson and Dow 2005), e.g. recovery time following shocks, size of the stability domain absorbing the shocks, resilience potential, entropy, transition probabilities, and break points; while other authors have tested several context specific variables though they remain at a theoretical level (Allison and Hobbs 2004, Reggiani et al. 2001). From an empirical viewpoint, however, they found resilience can be measured as the system's stability in the presence of change, mainly related to the size of surrounding steady-state conditions (SSC), a core argument of this thesis.

An empirical claim associated with the adaptive cycle model is the ‘rule of hand’ (Gunderson and Holling 2002), which states that for most systems, the adaptive cycle can be adequately modeled by a small number of approximately three to five key variables, the dynamics of which may occur at different time scales. With this in mind, this thesis offers a novel approach to assess FPS resilience. As food security is defined as having four distinct pillars, i.e. food availability, food access, food utilisation and stability, and in respecting the conditions set out by the rule of hand, the research proposed here assigns four resilience dimensions, one to each of the food security pillars, which are ecological resilience, economic resilience, consumption resilience, and social resilience, respectively. Ecological, economic and social resilience are processes reflective of their subsystems contained within a FPS, while consumption resilience indicates food security status in adaptive cycles. When applied to FPS, for instance, ecological resilience (and food availability) can be affected by climatic fluctuations and soil fertility depletion; economic resilience (and food access) can be impaired by eroding global terms of trade, market disruption during financial crises, non-farm income insecurity or the loss of a household’s productive assets and productivity via forced sales or losses during displacement; consumption resilience (food utilisation) can be negatively influenced by gender inequality in consumption, health and care factors, diseases and illnesses, nutritional quality, cultural preferences and food safety, cooking skills, and the loss of coping options, e.g. diet reduction; and social resilience (or stability) declines with the collapse of safety-net institutions that once protected people on low incomes. Definitions for each of the four dimensions of FPS resilience are given below, coupled with their respective food security pillar and time dimension in bracket:

- *Ecological resilience* (slow dimension) denotes land-use change in physical and natural wealth, effectiveness in terms of resource utilisation and waste minimisation, its ability to support social and economic resilience, as well as food utilisation, without undermining ecological conditions and the natural ecosystems in which it operates. Food availability is largely coupled to this base;
- *Economic resilience* (fast dimension) symbolises the financial wealth of the system, economic growth and diversity in which it operates, the food provision chain that it rests on, its labour and capital productivity, and increasing incomes over time and the markets that it serves. Food access is mainly tied to this resilience dimension;
- *Consumption Resilience* (outcome dimension) is distinct from the other three FPS resilience processes. It is a cornerstone of FPS resilience as nutritional status indicates place along the adaptive cycle and food regime level in which the individual participates in FPS. For example, it is possible for some individuals and household members are food insecure in households enjoying food security. Conversely, certain individuals are well nourished even in households that are food insecure overall. Measurement of individual food security, whose access to food is regulated by intra-household allocation rules and processes, requires measurement of individual food utilisation, the third pillar of food security. This measurement is of particular relevance in selecting food poverty thresholds for analysis to distinguish between the food secure, the vulnerable to food insecurity, and the food insecure; while

- *Social resilience* (mixed slow/fast dimension) is designated as the human, political, and cultural wealth of the system, including safety-nets, levels of education, institutional stability, social cohesion regarding FPS objectives, and both the political and cultural cohesion and enhancements of the standard of living of its host societies. This fourth resilience dimension is linked to the food security pillar regarding stability.

Table 3.2 - Proposed food system resilience variables according to the rule of hand and respective food security pillar and corresponding adaptive cycle factor.

Food Security Pillar	Food System Resilience Dimension	Variables	Corresponding Adaptive Cycle Factor
Food availability	Ecological	Land potential (or land use trends)	Wealth
Food access	Economic	Wealth productivity (Labour and or capital productivity)	Connectivity
Food utilisation	Consumption	Intra-household allocation (Gender inequality in food consumption, malnutrition)	Food security outcome, situates cycle in Panarchy Framework
Stability	Social	Safety-nets	Band of tolerance, Steady-state conditions

Regarding measurement, four variables are proposed below, each representing one of the four FPS resilience dimensions. A more detailed review of each of the resilience dimensions and justification for their selected variables is given in the following four

subsections. Table 3.2 summarises the FPS resilience variables suggested for each of the four food system resilience dimensions and their proper food security pillar.

3.3.2 Ecological Resilience

Land use involves both the manner in which the biophysical attributes of the land are manipulated and the intent underlying that manipulation, the purpose for which the land is used (Turner et al. 1995). Similarly, Meyer (1995) and Moser (1996) state that land use is the way and purpose for which human beings employ the land and its resources. Skole (1994) expands the argument further in that land use itself represents the means by which human activity appropriates the results of net primary production as determined by a complex of socio-economic factors. FAO (1995) states that land use relates to the function or purpose for which the land is used, i.e. FPS services and functions, by the local human population, and can be defined as the human activities which are directly related to land, making use of its resources or having an impact on them.

In the case of land use change, the relevant literature distinguishes between two types of change: conversion and modification (Turner et al. 1995, Skole 1994). Land conversion involves a change from one land type to another while land modification involves alterations of structure or function without a wholesale change from one type to another, e.g. changes in productivity. Changes to land are the result of natural, often hydrological, processes, e.g. El Niño, hurricanes, changes in river channels and sea level rise (adapted from Briassoulis 2000). However, most of the changes of the present and the recent past are due to human actions (Turner et al. 1995), e.g. Belize's colonial and recent history in

terms of land use for export and settlement (Babcock and Conway 2000, Moberg 1997). Meyer and Turner (1996) further suggest that land use, deliberately or not, alters the land in three ways: converting the land cover, or changing it to a qualitatively different state, i.e. towards a newly alternative self-organising adaptive cycle; modifying it, or quantitatively changing its condition without full conversion, while affecting SSC; and maintaining resilience in its SSC against natural agents of change.

Land use analysis requires an examination at various levels of spatial and temporal detail, common of food security dimensions, described earlier in subsection 3.1.3. The specification of FPS steady-state conditions (SSC) within a band of tolerance is of crucial importance for the analysis of both spatial and temporal changes as: (1) it guides the selection of the types of land use, land potential and ecological wealth that will be analysed, (2) it determines the drivers and processes of change that can be detected and, (3) affects the identification and explanation of the linkages and ecological resilience between land potential/use and focal socio-ecological frameworks and adaptive cycles (adapted from Briassoulis 2000). This last point addressing the specification of SSC further enforces previous arguments on the common application and transferable aspects of resilience developed in the context of ecological systems appropriate for coupled socio-economic and ecological frameworks. Lower-level land use changes may not produce significant land cover changes, however, they may accumulate across space and produce significant land cover changes for higher-level adaptive cycles, characteristic of revolts in Panarchy theory. This is the case, for example, of agricultural land conversion to urban uses that results from the decision of the individual land owners to convert their

farmland to non-farm uses. Similarly, land use changes may be more qualitative rather than quantitative at lower levels of spatial and temporal detail but they show up as quantitative changes at higher levels and in the longer-term. For example, gradual and incremental changes in the types of crops grown at the farm/local scale, or in the quality of land management, may result in the abandonment of agricultural land or residual degraded productive land, and ecological wealth typical of nested adaptive cycles in lock-in pathological states. Furthermore, longer-term factors reflect the opportunity and resilience costs of biodiversity loss or climate change and sea-level rise. For instance, Tucker et al. (1989) advocate the continuous use of a series of sequential indicators which focus on different temporal conditions. This would involve: (1) leading indicators, such as rainfall (ecological wealth, leading to food availability within normal SSC), which anticipate the need for intervention and the need to mobilise resources; (2) concurrent indicators, such as prices, market information, output per time worked (economic wealth, productivity, and food access), to trigger the implementation of interventions; and (3) lagging indicators, such as anthropometry (food utilisation), to measure food security and nutritional status, and safety-nets (social wealth) to measure the impact of interventions.

In a review of case studies of land use change around the world, Lambin et al. (2001) concluded that economic conditions of export oriented economies, for instance, were the predominant factor that controlled individual and social responses. Although conditions were context specific, land use change was mediated by institutional factors, defined broadly as the set of rules, or structures, that allow people to organise for collective

action (Gunderson et al. 2002), such as place, history, colonial past, government policies, and safety-nets; factors increasingly influenced by global markets, e.g. exports and prices, and that extreme biophysical events could occasionally trigger further change. This combination of factors needs to be conceptualised and used as the basis of explanations and models of land use change (Allison and Hobbs 2004).

Lastly, ecological resilience typically depends on slowly changing variables such as land use, nutrient stocks, soil properties, and biomass of long-lived organisms (Gunderson and Pritchard 2002), which are in turn altered by human activities and socio-economic driving forces (Lambin et al. 2001). The increase in social and economic resilience as a consequence of increased vulnerability to food insecurity, land degradation and drought may cause losses of livelihood and trigger tension and conflict over critical ecological wealth such as fresh water resources or food (Homer-Dixon and Blitt 1998).

3.3.3 Economic Resilience

Leading indicators of food access crises discussed in the literature include crop failures, decline of livestock herds, and a decline in local economic activity and conditions such as labour and food allocation (Maxwell and Frankenberger 1992). In areas which are less well-integrated into regional economies, distinctive of lower-level dissipative adaptive cycles, and in which food security is largely determined by impoverishment, i.e. a state of having little or no wealth, early indicators of land use change, price declines, food safety breaches, and labour productivity shortfalls are useful. Conversely, areas which have better links to external markets, income and food sources, are more resilient to

fluctuations in domestic food availability. That is, markets, irrigation structures, electricity and credit systems are often in place, and information and capital flows are greatest where agriculture is already productive and where population density is sufficient to meet labour demand. However, the time-varying nature of agricultural work enables small-holders to search for complementary employment, building resilience in efforts to fight marginal labour productivity declines (Boserup 1993). On examining agricultural growth, Boserup (1965) argued that the key to persistent underproduction in subsistence agriculture is the marginal productivity of labour. While intensification in non-mechanised cultivation causes the productivity of land to increase, it also causes the productivity of labour to decline (increasing vulnerability of agricultural producers) as argued by Tainter (2006). Consequently, subsistence farmers often produce less than they might for the simple reason that increasing production yields diminishes returns to labour. In resilient FPS, small producers can achieve food security on relatively infertile, even degrading soils when their wealth, e.g. income sources, is diversified and protected from a dependence on unreliable rainfall, ensuring more sustainable food security outcomes. As such, income diversification is important for coping with change, thus reducing income variability and enabling consumption smoothing over time (Rubens and Pender 2004). For other households, however, investment in land productivity may represent a viable option towards both short and medium-term food security, where, for example, a market exists for products of labour-intensive agriculture, often the case of cash crops (see Roebeling and Ruben 2001 for an example in Costa Rica).

Since the rural poor control mainly labour and less-favoured often degraded lands (adapted from Barrett 2005), interventions to boost labour and agricultural productivity in these lands will assist in building FPS resilience and reducing vulnerability margins to food insecurity. As their productivity is affected by both nutrition (Bonnard 2001) and the price of food as they spend a larger share of income on food (Timmer et al. 1983), labour productivity growth in the agricultural sector may further improve resilience and increase food security. Productivity is the key factor for both economic resilience and food access as a measure of food security. As dissipative regimes grow in wealth, connectivity and diversity, and as labour productivity reflects economic growth and changes in other factors of production, such as capital, labour productivity is replaced with capital productivity as the sentinel variable.

3.3.4 Consumption Resilience

Food systems reflect entrenched interests and processes (Fine 2002). How consumers understand food is bound by what they understand by health, diet and nutrition, which may differ from beliefs about what is good, natural or unhealthy. Food beliefs are diverse and complex given the cultural content of food and, how food is experienced (Fine 2002). The author adds that it is not simply a matter of taste and reflection but how we buy, prepare, eat, dispose of and socialise around food.

Food utilisation provides the food security status of participants in FPS. Food utilisation relates to individual level food security and is the ability of the human body to effectively convert food into energy and nutrients according to health, nutrition and care factors.

Food insecurity is an outcome measurement relative to FPS thresholds (Figure 2.6) based on availability, access, utilisation, and stability, represented by food utilisation. The latter incorporates issues of preference and culture, food safety, quality, health and consumption while efforts to assess food utilisation would likely employ indicators of consumption, nutritional status inequality around consumption.

Such measurement of individual food security is regulated by intra-household allocation rules and processes. Common to food security measurement, the household is most often considered the logical social unit through which to view the question of access to food, in spite of intra-household inequities in the distribution of food (Bentley and Pelto 1991). Maxwell et al. (1999) have critiqued the household approach: (1) this demands not only knowledge of overall household needs and consumption, but also an understanding of intra-household dynamics affecting procurement and distribution of food; (2) household food security should be considered a necessary but not sufficient condition for adequate individual nutrition; and (3) food security must be understood in terms of the rationality and logic of the persons or social units involved. Acquiring food and the provision of adequate nutrition are among the most basic of human pursuits as human beings are not simply passive victims of either adequate or inadequate nutrition (de Garine 1972).

Entitlements are often household-based and the distribution of food depends on intra-household relations. Evidence suggests that intra-household allocation of resources depends on individual wealth position and labour activities as well as other factors such as gender (Haddad et al. 1997). Paramount to FPS resilience, gender affects the

distribution of resources and wealth: identifying an individual's differential access to economic, social and ecological wealth and benefits is the fundamental feature of gender analysis, and ensuring equitable intra-household access and distribution will enhance both food security (Quisumbing et al. 1995) and FPS resilience. As argued earlier, women also provide the majority of care for their families, take their children to health services, and ensure a healthy environment, the very components of good nutrition and food utilisation (Levin et al. 1999). Quisumbing et al. (1995) also emphasised the strong relevance of intra-household allocation in determining food utilisation.

Food utilisation can thus be represented by intra-household allocation, through gender inequality in consumption, and thus dietary energy intake, through nutritional status. However, the merits of collecting food intake data at the individual-level for the purpose of understanding intra-household resource allocation issues remain contentious (Fuwa 1998). Any analysis to observe changes in the per capita consumption at the household level due to a change in the sex composition in the household, will be required to make inferences on gender inequality in dietary energy intake and nutrition. Gender inequality, related to food allocation and consumption, will lead to malnourished pregnant women, and underweight children that are at greater risk of not living to their fifth year (Saith 2005). It requires disaggregating the reallocation of resources by sex, because food production, income control, expenditure decisions and activities are all part of the gender division of labour (Katz 2000). In particular, the labour intensity of the crops, the strength of alternative income sources for women, and the character of intra-household income transfer arrangements, jointly influence FPS resilience by the degree to which revenues

from cash-crop/food crop farming are devoted to women. Given the greater role women play upon maintaining or improving individual, e.g. household member, and household food security, gender inequality constrains FPS resilience.

It is of interest to understand the opportunity costs of reduced consumption variability (Alwang et al. 2001), meaning the cost of variability on food security based on gains from consumption resilience as a better alternative, i.e. in this case, increased consumption resilience by smoothing FPS components. In effect, there is mounting evidence that by enhancing the ability of the food insecure to cope with risk, important longer-term impacts on productivity and efficiency can be achieved (van der Walle 1998, UNISDR 2002). Holzmann and Jorgensen (2000) also point out support for better resilience management among food insecure FPS participants can also enhance the welfare distribution and societal welfare without actually redistributing income among individuals. Additional empirical work suggests that in circumstances of high poverty mobility, greater gains can arguably be made from smoothing fluctuations and uncertainties than in simply seeking to reduce the percentage of total households below a fixed poverty line (Yaqub 2001). For example, in Vietnam it has been estimated that the national incidence of poverty could be reduced to 34 percent by implementing conventional growth policies, but this would carry the penalty of increasing national income inequality to 0.38 (Gini coefficient). By contrast, the generation of less but more stable growth (more stable over time at the lowest end of the income distribution resulting in a Gini of 0.30), would allow the poverty rate to fall to just 22 percent of the population (World Bank 1998). The better distribution of income (economic wealth) and

greater stability (4th pillar of food security) in that distribution, results in greater income gains overall, improving food access (2nd pillar), which is essential for smoothing food consumption and buffering fluctuations in nutritional status (3rd pillar) (Webb and Rogers 2003).

3.3.5 Social Resilience

Regarding social resilience, safety-nets and social protection provide opportunities to accumulate wealth, climb out of food insecurity, and build more resilient livelihoods for systems affected by change (Barrett et al. 2002, Kabeer 2002). Social protection relates to how public actions designed to help people manage change. In the absence of effective collective arrangements to manage such change, individuals and households are forced to engage in micro-level informal management strategies which frequently impose very high costs of their own and may still prove ineffective (Conway and Norton 2002). For instance, Scott (1976) found that risk-avoidance behaviour has coloured how small-scale farmers manage subsistence agriculture: generally, cultivators prefer to minimise the probability of a disaster rather than to maximise average return. Walker and Ryan (1990) found that households in semi-arid areas may sacrifice up to 25% of their average incomes to reduce their exposures to acute change. Conversely, coping strategies, undertaken to relieve the impact from change once they have occurred, are a FPS resilience response to the depletion and loss of wealth. FPS participants unable to fully adjust to change, become vulnerable to food security, even food insecure, further constraining their resilience to respond to any future changes in FPS. Their wealth may be minimal and thus they are rendered destitute by the smallest income loss, running the

risk of irreversible damages to their wealth base (Behrman, et al. 2004, Alderman et al. 2003), and of falling into a pathological poverty trap. Following Maxwell and Frankenberger (1993, p.29), “coping may be a misleading positive word, implying that food insecure households survive periods of high risk unscathed. In fact, households may survive only at cost of significant impoverishment.”

Assisting systems to reduce exposure to risk while improving resilience will help develop social wealth and raise food security levels during crises at the cost of exploitation allowing the food insecure to take calculated wealth investment risks that will have positive effects on FPS resilience through wealth and connectivity growth. Social safety-nets can be conceptualised as publicly funded transfer programmes with consumption smoothing objectives (Devereux 2002) as even small income transfers are often invested in income-generating activities, education, social networks, or the acquisition of productive assets. This suggests that social safety-nets can alleviate transitory and acute change to livelihoods, and play a significant role in reducing chronic wealth deprivation and consequently food insecurity.

Safety-nets that help households to reduce exposure to risk and deal with adverse events can help them to develop FPS resilience, and prevent falling below the vulnerability and food insecurity thresholds. Social protection strives not only to prevent falling below the thresholds such as through homeostatic mechanisms but minimise the depths to which the vulnerable and food insecure may fall and rebuild quickly following the impact from

change. It is not the focus of this thesis but the right to food 'falls' into this category and is part of social protection.

While social norms assist in the reorganisation and growth adaptive cycle phases (Carter and Castillo 2005), both phases of the adaptive cycle, Carter and Castillo (2003) argue that work on social wealth needs to pay more attention to the rules of inclusion and exclusion in social processes; as endogenous social effects are revealed, meaning that individual, household and community social wealth are self-reinforcing, part of the self-organising principle in adaptive cycle formation and renewal. Social protection also includes programs designed to mitigate the adverse effects from acute and chronic change to improve wealth levels through interventions in:

- labour markets, e.g. employment, microfinance and rural credit;
- social sectors, e.g. education, health, and nutrition programs;
- safety-nets, e.g. transfer programmes, consumption smoothing, and safety-ladders, i.e. the laddered assistance ranked by resilience capacity or the ability of FPS participants to return to the reorganisation or conservation phases and above food poverty thresholds, i.e. adaptive cycle location or nested among a pathological trap; and
- the evaluation of migration patterns and remittances that may further improve food security levels and food system resilience.

Although recent work on social protection has focused either upon global donor policy or local-communities (Conway and Norton 2002), the analysis in this thesis addresses social protection measures at the national level.

3.4 Chapter Inferences

FPS are often viewed linearly from supply to consumption, and lose their cyclical, looping and dynamic nature (Fine 2002, Malassis 1973, 1975). As a result, FPS have need of better conceptual and applied tools to evaluate the extent to which FPS can be made more robust (Fraser et al. 2005). In response to this research gap, this thesis, as set out in Chapter 2, focuses on developing a FPS resilience framework. Fundamental to this framework are concepts of food security and food systems. This chapter has presented both essential concepts, and in combination, defined a four-dimensional view of FPS resilience with illustrations for (1) each of the three processes, ecological, economic and social resilience, and for (2) consumption resilience, an outcome measurement of food security. The rest of this section will discuss FPS, to evoke a novel food paradigm, a fresh way of conceiving problems and solutions about food security, a paradigm in which a robust and efficient FPS resilience framework now plays a significant role in achieving food security.

FPS stand for the infrastructure and mechanisms which underpin food security. A well-integrated FPS has the capacity to provide stability that will significantly secure food availability, access and utilisation. There is a strong element of variability when defining change: changes within observed variability parameters within a known range and rate of

recurrence may be considered normal; when changes become more frequent and or severe, outside steady-state conditions, they are considered shocks and disruptions to FPSs. It is the interaction of the change, e.g. drought, or the devaluation of a currency, the introduction of biotechnological/novel foods, or the arrival of supermarket chains; with the properties of an exposed system and its socially constructed vulnerabilities that result in a particular outcome (adapted from Adger and Kelly 1999, Pelling and Uitto 2001).

It is essential to recognise that there are significant cross-scale interactions, due to the interconnectivity and panarchical relationships between FPS. Processes and factors proximate and distant from the impact of a disturbance determine these socially constructed vulnerabilities (Cannon 2002). These root causes can be institutional factors, or more generally political, economic and social processes, often highlighted in food security work (Maxwell and Slater 2003). FPS that are repeatedly put under stress by threats and institutional variability (source of instability) tend to move from predictable to volatile food system cycles (Pingali et al. 2005). For instance, these authors argue the risk of decreasing FPS functions and provision of services in specific FPS becomes high when the society has been heavily affected by an attenuated public sector, and loss of market and/or institutional structures.

FPS vulnerabilities to changes are partly a function of diversity, the wealth of the system, its interconnectivity, and its political environment (Fraser 2003, Lang and Heasman 2004). This latter environment is determined by social, economic and institutional structures that reflect the power relations of any given society, e.g. wealth, entitlements,

assets (Cannon 2002, Sen 1981, Watts and Bohle 1993). Therefore, food security is highly contextualised. These relations have to be traced along a chain of causation (i.e. loop) back to the processes and forces that determine the distribution of security, vulnerability and insecurity in society. FPS resilience can then be seen as a term that encompasses all levels of exposure to changes along a scale from food insecurity, vulnerability to food insecurity, towards achieving food security.

Although provision is implied in FPS, the term provision is made explicit in this thesis to emphasise the fundamental acts of supplying and acquiring food in an evolving system calling attention to its dynamic nature. This differs from other FPS approaches (Thompson 1995), those mirroring the current dominant political economy of food and agriculture, a productionist (Fordist) paradigm, one focused on producing food commodities and food availability, a result of processes that are not based on nutritional need but on wealth (Cannon 2002). Under this paradigm, the FPS is viewed linearly, and at the heart of which lies the means-end distinction (Borgmann 1984). A sustainable FPS's desired end-point is the maximisation of food security for all participants of the system, each with their own relevant characteristics (Campbell 1998), and priorities, though the level of analysis must be the FPS as a whole (Dahlberg 1993, Thompson 1995). Consequently, the FPS will be analysed through a soft system lens. The soft systems perspective says only that it is useful to view the world as if it were composed of systems (Thompson 1995).

The concept of paradigms was first developed by Wittgenstein (1889-1951) and adapted by Kuhn (1970) to science as a process of generating ideas. If a paradigm is a set of assumptions from which new knowledge is generated, a way of seeing the world that shapes intellectual beliefs and action, then science is a process expressing values in its facts. Lang and Heasman (2004) use the term 'food paradigm' to indicate a set of shared understandings, common rules and ways of conceiving problems and solutions about food. A paradigm is thus an underlying fundamental set of framing assumptions that shape the way a body of knowledge is thought of. The above authors have proposed a food paradigm for public policies that prioritise all food security pillars not only availability: a paradigm that preserves and integrates ecological diversity with population health and society, through the study, design, and management of systems with a view of productivity, while conserving natural resources, to systems that are culturally sensitive, socially just and economically viable. The proposed FPS resilience framework fits well within the food paradigm.

In sum, reducing food insecurity and rendering FPS tenable, requires an understanding of the constraining and enabling factors, and the dynamics between factors, which provide for the nutritional needs of consumers. According to Fine (2002), diversity, flexibility and perpetual change define systems of provision. Such systems bear in mind the proximate factors affecting production, exchange, distribution and consumption, but also more distant and remote processes that affect FPS such as trade, delivery, and transport. Systems of provision are precipitations of meanings, structures, activities and inter-relationships around particular history, and spatially contingent, and vertically oriented

features of FPS (Fine and Leopold 1993). Atkins and Gasconi (1997) further extend this characterisation of FPS to include: social consequences of food consumption, especially as health, (1) will become a driving force in the food chain during the 21st century (i.e. eco-public health paradigm, Lang and Heasman 2004), and (2) the analysis of location-specific provisioning systems will illuminate some features of structure and process.

Chapter 4 – Food Security and Vulnerability Assessments

Previously asserted in earlier chapters, more attention is traditionally given to short-term vulnerability and food insecurity because of the urgency and immediacy of emergency situations. Less emphasis is placed in methodologies on identifying and analysing the longer-term impacts to food security, which require a set of interventions different from emergency or humanitarian responses. It is an objective of this thesis to develop and implement a comprehensive FPS resilience framework for integrating longer-term aspects of food security as current FPS resilience analysis are largely non-existent, and as most existing vulnerability analyses focus on transitory food insecurity.

The thesis proposes to address the resilience issues raised in Chapters 2 and 3, strengthening the foundation for achieving food security by reducing vulnerability and enhancing FPS resilience. Several approaches to assess food security will be reviewed and appraised in this chapter, including methods and practical tools from a number of different sources chosen partly from field experience, partly for their contribution and engagement in promoting food security. This chapter will thus be confined to common methods, used by development and donor agencies in particular, that use statistical tools, geographic information system-based mapping tools, vulnerability assessments, most having been designed to assess the food security status of a population, and implemented and analysed quickly to generate information that can be used to inform emergency food security and vulnerability programming. Their descriptions will help contrast their

procedures with the FPS resilience framework, inform FPS resilience interpretation, and identify criteria for FPS resilience analysis conducive to reducing food insecurity.

4.1 Short-Term Food Security Assessments

Ideally, we want to know not just who and where the food insecure are situated within their respective FPS food regime, but also where these adaptive cycles are located in terms of wealth and connectivity, and in relation to other lower and upper FPS adaptive cycles. In addition, knowledge of whether their food insecurity status is transitory or chronic, or information pertaining to their level of vulnerability to food insecurity, is relevant in attempting to situate FPS participants with reference to their adaptive cycle SSC and food poverty threshold positions.

Short-term assessment methods may focus on changes to food security through early warning systems and vulnerability mapping, while other methods focus on livelihoods analysis using baseline food economy studies or a household economy approach (O'Donnell 2005, SC 2004, Seaman and Petty 2005). Other methods try to represent a collation of existing data from these methods, with additional information derived from field surveys. However, many of these and other methods have a strong short-term food security focus, e.g. methods developed around dietary diversity scores (Hoddinott and Yohannes 2002, WFP 2005); coping strategies index (Christiaensen and Boisvert 2000, Maxwell et al. 1999); household self-assessment (Devereux et al. 2003); and famine scales (Howe and Devereux 2004). These methods share common characteristics that make them useful for assessing food security status, notably at the household level but

limit their usefulness for the specific purposes of distinguishing between chronic and transitory food insecurity (Devereux 2006).

Main disadvantages of dietary diversity scores, coping strategies index and household self-assessment methods are that they generate relative measures of food insecurity rather than absolute food gap measures. They provide a cross-sectional view and require repeat analysis and monitoring to determine whether food insecurity is chronic or transitory. With no contextual information, it is difficult to identify appropriate interventions; and they are locally-based, assessments which present challenges in patriarchal relationships between FPS scales (adapted from Devereux 2006). Household economy approaches provide stronger baseline and contextual information about livelihoods; and analyse the causes and consequences of chronic and transitory food insecurity. The famine intensity scale has the advantage of providing absolute rather than relative measures of food insecurity. Adding stunting to the nutritional surveillance component can help to differentiate between chronic, transitory, and composite food insecurity. Devereux (2006) recommends that these tools be used in two ways: to provide baseline information on food security conditions and local livelihood systems; and build a profile of chronic and transitory food insecurity over time, as part of a food security monitoring system. No single methodology can fulfil both functions. Instead, a combination of baseline and rapid assessment methods is suggested.

4.2 Food Supply Assessments

In order to match resources to specific food security problems, it is necessary to understand the baseline food security situation of affected populations before food security degradation occurs. In many cases, this information will already exist from secondary sources. For example, most food insecure countries have annual Crop and Food Supply Assessment Missions (CFSAMs), which generate a range of data on relevant indicators, updated during the season and year to year.

CFSAMs are used by the Food and Agriculture Organisation (FAO) and World Food Programme (WFP) and are mounted for disaster assessment purposes (short-term focus) in response to a government request for emergency food assistance or when one is anticipated (FAO 2000). They are also undertaken when there is a need for an independent and critical assessment of local information on food availability, i.e. food supply, demand and food security and nutrition status of vulnerable groups. The annual FAO/WFP CFSAMs are conducted during or following the main harvest periods to inform macro-level analysis of food and production deficits.

CFSAM's overall approach uses estimates of the food supply and demand situation in the forthcoming marketing year based on supply utilisation accounts (SUA) or national food balance sheets (NFBS). SUAs are time series data which put together and compare statistics on food supply and utilization. On the basis of SUAs, NFBS are prepared. A NFBS presents a comprehensive picture of the pattern of a country's food supply and utilisation during a specified reference period, usually one year or an average of a number

of years. The total quantity of different foodstuffs produced in a country, increased by the total quantities imported as well as adjusted by stock changes, gives the supply available during that period. On the utilisation side, a distinction is made between the quantities exported, fed to livestock, used for seed, processed for food use and non-food uses, and lost during storage and transportation; and the food supplies available for human consumption. The per capita supply of each food item available for human consumption is then calculated by dividing the respective quantity by the population number. Data on per capita food supplies are expressed in terms of physical quantities and also, by using food composition tables and applying respective conversion factors, dietary energy, protein and fat.

NFBSs portray the overall food situation of a country and offer an assessment of the state of national food security based heavily on food supply figures. Though, if the quantity of nutrients available for food utilisation, as calculated by the NFBS, is smaller than the aggregate nutritional requirements, the country has an obvious food deficit and is food insecure at a macro-level. Once NFBSs are developed, the CFSAMs then assess the food situation at the sub-national level and issues related to the affected FPS participants.

A limitation of the CFSAM approach, is that it monitors data on food supplies and market conditions, rather than food security conditions at the household level like the short-term food security assessments. While NFBS are, in principle, a useful instrument to analyse national food supply and to identify major production and supply deficits and trends, NFBS also reveal certain limitations, e.g. NFBS only provide average figures for the

whole country and do not take account of any differences in distribution between communities, households and household members or FPS participants; and NFBS only show the amount of food available to consumers but not the food actually consumed and the nutrients actually utilised. Therefore, in order to get a more comprehensive picture on FPS resilience at a national or macro scale, NFBS analysis need to be complemented by other methods such as vulnerability assessments.

4.3 Vulnerability Assessment (VAC)

Early warning systems on the other hand, monitor the periodic assessment of factors influencing food availability, access, utilisation and stability, the four pillars of food security, for communities, particularly vulnerable to shocks and acute change such as drought, conflicts and other factors that may lead to rapid and acute declines in food security status. They try to predict future changes in food security status and alert for the need to adjust on-going interventions or initiate new interventions to meet emerging food security threats. In practice, it is necessary to establish a geographic basis for analysing the country, such as a small administrative unit or an agro-ecological zone. Using socio-economic, health, nutrition and other parameters, the degree of insecurity and coping strategies can be provided for these areas.

Famine related early warning systems (FEWS) use such vulnerability assessments to evaluate components of national and household food security to identify where and which people are food insecure, the nature of their problem, factors that would influence their food security, and possible interventions. It uses a livelihoods approach based on food

economy and household economy approaches. This information is commonly used to help decision-makers select types of action required to protect or improve the food security of a population (e.g. unit of intervention, provider group along the food chain). The outcome is a classification of populations living in different areas by degree of food insecurity, a first screening for targeting assistance in emergencies, and at times in the longer-term.

Central to the approach are assessments of baseline vulnerability at the start of the crop season focusing on underlying processes encompassing the previous few seasons, or years. The baseline assessment is subsequently updated as the season progresses, reflecting the current risk of famine based on, for instance, the projected harvest, prices of staple foods, food stocks and food aid deliveries. In contrast, the WFP's Vulnerability Analysis and Mapping (VAM) project defines vulnerability in terms of food security as the probability of an acute decline in food access or consumption levels below minimum survival needs. WFP differentiates the need for food aid between populations and areas. The last decade has witnessed a number of technical and organisational developments in relation to food-related vulnerability, which have resulted in the concept of vulnerability, and approaches to it, being refined and also to an increased interest in spatially representing differences in vulnerability (DFID 2003). Such approaches use vulnerability mapping guidelines to locate the geographic areas where people are vulnerable, an approach that requires access to existing geo-referenced data and effective use of GIS technology. It is a result of both exposure to risk factors (stressors), such as drought,

conflict or extreme price fluctuations, and also of underlying socio-economic processes which reduce the capacity of the food insecure to cope.

Vulnerability assessments, the second in the series of methods reviewed in this section, provide a basic understanding of the determinants of food insecurity and vulnerability by location and social group, as briefly introduced through examples from VAM and FEWS. Vulnerability assessments differ from food security assessments only in their greater emphasis on risks that the unit of study, e.g. households or countries, face in their production, income and consumption, as well as the threat of rapid and acute declines in food utilisation and nutritional status. When conducted on a location-specific basis, vulnerability assessments often lead to one or a series of maps that characterise the regional dimensions of risk and coping capacity. Below, two methods are appraised for their use and identification of food security indicators in presence of multiple stressors: a vulnerability assessment, and a food insecurity and information early warning tool.

The Southern Africa Development Community Vulnerability Assessment Committee (VAC) matches these methods in that it: (1) provides sub-national food aid targeting requirements, including a breakdown of socio-economic groups and special needs targeting, e.g. HIV/AIDS, child supplementation; (2) informs and guides on-going food security monitoring at the sub-national level; and (3) re-assesses estimated needs in the light of new events as the year unfolds. The mandate of the VAC is to keep abreast of and encourage co-ordinated development in the field of vulnerability and livelihoods assessment in the SADC region (DFID 2003).

The VAC is neither an alternative, nor a wholly new method of vulnerability assessment; rather it represents the collation and coordination of data from existing sources and supplements these with additional information derived from periodic in-country surveys. Of interest for the Caribbean as a potential regional food security assessment method, VAC assessments provide an umbrella forum for discussion, and on-going monitoring of key food security indicators in each country, consistent across the region.

The VAC methodology has two main elements: the collation and analysis of existing secondary data from the several collaborating agencies, and the collection of primary data using field teams in each country. The two sets of data are then brought together in a set of final reports combining macro and micro data and tailored to the needs of particular parties. Primary data is collected using a combination of focus group discussions, key person interviews and actual house-to-house visits in selected areas, including an urban sample. A livelihoods map is created that combines baseline studies with stressor/shock/hazard information to arrive at problem identification. From this, various outcome scenarios or risks can be assessed. The VAC has, for example, informed targeting priorities for national governments, WFP and its partners. Such assessments are significant for on-going and future planning exercises and are a way of measuring which people are food insecure and where to address weaknesses in the food system.

The other approach appraised in this sub-section for food security assessment is related to food-security monitoring systems similar to an early warning system though organised around the following four main themes (FAO 2000):

- agricultural production monitoring (APM);
- the market information system (MIS);
- monitoring of vulnerable groups (MVG) and poverty; and
- food and nutritional surveillance systems (FNSS).

These four themes are generally country-wide and linked to the statistics services of each of the ministries concerned. The creation of a Food Security Information and Early Warning System (FSIEWS) by the national bodies responsible for supplying food security information should not overlook any of these aspects but take them all into account in addressing food insecurity due to multiple stressors. These four themes are central to the development of a global system, offering a complete picture in combination. They also address the pillars of food security by monitoring:

- food *availability* (production + imports - exports - losses) supported by monitoring information on both production (APM) and foreign trade supplied by the MIS;
- *stability* of supplies uses data mainly from the MIS, as well as data on the status of infrastructure and stocks;
- *access* to these supplies should take into account mainly social indicators (MVG), e.g. poverty, unemployment, migration, etc.;
- and *biological utilisation* using data acquired from health and nutritional monitoring by FNSS, e.g. principal foods consumed by households, region, dependency rate and size of households, habitat, morbidity, the vaccination rate,

the weaning age, availability of and access to drinking water, and status of sanitary installations.

Its appeal is that FSIEWS relies on existing structures, involves all the actors in food security in the implementation process and therefore works through national consensus consequently building FPS resilience, and ensures that cross-analysis of the information systems is carried out at various levels by groups of different actors.

4.4 Composite Indices

The last alternative approach reviewed in this section on FPS assessments is on the generation of composite indices. Concerns guide the development of indices by the nature of food security as established earlier as it is difficult to make decisions when dealing with numerous and disparate dimensions. A composite index may assist efforts to fight food insecurity by effectively (1) aggregating the various dimensions of food security to provide an assessment of the manner in which different areas/countries or populations may be compared, as it identifies the food insecure; and (2) reducing multiple dimensions into a single measure, though potentially masking valuable information.

Generally an index is the composite of several indicators. In constructing a range of food security indicators, defining criteria against which to judge the utility of indicators for the purposes of a food system is necessary. For example, the sale of livestock in a market, a form of economic wealth, used by herders is generally an indirect indicator that food security will worsen for their families as their adaptive cycle shifts from transient to

absorbing SSC; or such as meteorological data helping to estimate future cereal production from rain-fed crops; or the combination of falling commercial stocks and transport difficulties, and poor road conditions at the beginning of the wet season is an indicator of rising short-term consumer prices. Below are four examples of indices used and remodelled by development organisations, each index representing different disciplines such as economics, vulnerability, environment and sustainability.

The Caribbean Development Bank has developed an economic vulnerability index (EVI) covering 95 countries as a measure of development. The EVI identifies five factors that contribute to economic vulnerability: peripherality and energy dependency, export concentration, convergence of export destination, reliance upon external finance and susceptibility to natural hazards (Cowards 1999).

The United Nations University Institute of Advanced Studies has developed a geographic vulnerability index (GVI) covering 100 developing countries as a possible extension of other economic vulnerability approaches. Its main purpose is to measure geographic vulnerability, with special reference to small-island developing states. The GVI identifies four dimensions of geographic vulnerability: insularity, peripherality, population concentration, and susceptibility to natural hazards (Turvey 2002).

The Commonwealth Secretariat has developed an environmental index meant to be applicable to developing and island states compiled for 111 countries. Six indicators were selected to reflect pressure on the natural environment: annual rate of deforestation,

population density, annual water use as a percentage of total water resources, ratio of coastline to land area, ratio of threatened species to land area, and ratio of total number of natural disasters to land area (Atkins et al. 2000).

Finally, a World Economic Forum task force produced an environmental sustainability index calculated for 142 economies, using 64 individual variables covering five components fundamental to environmental sustainability: environmental systems health, environmental stresses and risks, human vulnerability to environmental impacts, social and institutional capacity, and global stewardship (World Economic Forum 2005).

There is a certain amount of subjectivity in such indices through variable and weight selection. The four indices deal in particular with economic and environmental vulnerability but remain weak on social vulnerability. Additional social and resilience variables need to be added as there are concerns related to sustainable development such as diseases, labour migration, weak governance and institutional variability, for instance. The thesis picks up on these themes in Chapter 7.

4.5 Suitability of Methods for FPS Resilience

To gather further support, food security assessment tools must respond to certain criteria such as simplicity and suitability, and longer-term interventions ensuring greater food security activities, activities which seek to increase FPS resilience to future shocks and change. This section takes a critical look at the methods appraised in the previous sub-

section. The review weighs up on both strength and weaknesses to implementing and conducting food security and FPS assessments.

Most of the indices working on food security, the environment or sustainability, and vulnerability, use *available* statistical data as the food insecure are identified through different statistical analyses like correlation, regression, normalisation, composite indexing, and cluster analysis. When measuring national food availability, statistical analysis is generally based on aggregated data on the country level, i.e. NFBS. Until recently, assessment methods had been country rather than regionally based (FAO 2000). And for the most part, they remained reliant upon macro data pertaining to early warning on national food deficits, crop production and weather patterns, e.g. CFSAM assumptions rest on a three-tiered system of meeting food deficits: commercial imports, government imports, and international food aid.

There is typically a high degree of overlap in the basic indicator types required to meet the various decision-making needs, with differences related primarily to a specific analytical focus and employed data collection methods. Such methods include NFBS, crop surveys, household income and expenditure surveys, individual food intake surveys, anthropometric indicators and qualitative measures of food insecurity. For instance, data from human growth monitoring activities (e.g. height and weight) may be quite useful in a program context to identify the need for supplementary rations in individual cases of under-nutrition or growth faltering and to show basic overall trends in food security conditions. However, given the limited geographic coverage of clinical-based growth

monitoring, rapid anthropometric surveys are often also necessary to target more general feeding programs in an emergency context. Similarly, alternative methods may use measures of per capita crop production as an indicator of food security status, another more concerned with long-term averages in production, while another focusing primarily on production data related to the most recent harvest.

Admittedly, there is a multiplicity of useful information from the four food security monitoring components (pillars), availability, stability, access, and utilisation, as was suggested by FSIEWS, but collection may be difficult, either of primary or secondary data. Data may seem superfluous to policy-makers and other food security information users but a survey of potential users can help clarify precise requirements, in respect of both how the information is prepared for use, its periodicity and medium as methods for assessing food security depend on the purpose and level of measurement. There is tension between the information requirements for immediate and long-term assessments as a means for generating baseline information for food insecurity alleviation and development strategies. Similarly, trade-offs are regularly made on methodology design and analysis, pressured by time constraints and negotiation.

The VAC methodology estimates needs for food security analyses for typical households, i.e. grouped by wealth measurements. By factoring-in subsistence production with income-based food purchases, a household food gap is estimated as that which must be covered with food assistance. The aggregated household food gaps represent the national

food assistance requirements. The VAC methodology then captures both transitory problems of food availability plus chronic problems of inadequate food access.

However, emergency operations are, by definition, an effort to offset the worst effects of *transitory* food insecurity, and tend to target the most affected people or regions. *Chronic* food insecurity on the other hand, exacerbated by structural deficits, e.g. disease, weak economies, institutions, points to the need for longer-term social resilience. The VAC assessment approach identifies all households that fall below the minimum per capita food requirement thus layering households by income and wealth scale. For instance, medium income households that do not have access to food would be included if their various sources of income fell below a certain threshold. These households may, however, only be included in assistance programmes towards the end of the production year, in contrast to the poorer households that are often targeted earlier on in the year, reflecting the increase in the number of people in need over time. This method can thus identify annual needs from seasonal needs. However, it is not adequate for identifying rapidly changing scenarios, something that would require greater monitoring rather than short intensive surveys, or 'rolling assessments' to address sample size changes and scale issues.

4.6 Chapter Inferences

There are a number of approaches to quantify and qualify food insecurity due to ecological and socio-economic changes. To study increasing food insecurity due to such changes, this chapter reviewed selected instruments for assessing vulnerability and food

security. The review shows it takes many indicators to understand the complex nature of food security, of the threats FPS face, and the extent to which FPS participants can deal with these changes. The methods reviewed in this chapter further affirm the foundation of the FPS resilience framework designed in Chapter 2, owing to experience gained from methods with a focus on emergency or humanitarian assistance, with a focus on economic wealth, assessments useful for short-term FPS resilience, though neglecting chronic structural FPS issues. This asserts Ellis' (2003) argument that the role of such approaches has been at the expense of exploring larger causes of vulnerability at the national level, and has added little in terms of longer-term resilience studies. Countering the latter research gap is an objective of this thesis.

Chapter 5 – Analytical Challenges, Methods and Data Sources

How should an assessment be conceptualised and realised? How does one choose the right instrument from among potential methods available, and the right FPS resilience variables from among potential data sources? The rule of hand steers this selection by focusing the research upon the four FPS resilience dimensions matching each of the four food security pillars. This chapter starts by addressing these questions beginning with the manner in which this thesis meets current analytical challenges in the literature for assessing the resilience of food systems. The chapter then examines how Belizean FPS were selected for study, details survey methods implemented in Belize, along with secondary data pulled together for this research. Particular attention is given to the GoB's 2002 Living Standard Measurement Survey (LSMS) as these assessments support a major part of the explanatory research results for the empirical segment of this thesis.

5.1 Answering an Analytical Challenge

Eakin and Luers (2006) have recently summarised major trends in the literature on social and ecological vulnerability, and their conclusions are relevant for the task of analysing the resilience of food systems in this thesis. They propose that there are four analytical challenges (CH) for assessing the vulnerability of complex socio-ecological systems which parallel the resilience of food systems:

- First (CH1), is how to address the combined effects of multiple stressors acting upon a system, as it is difficult to identify links among them or determine cause

and effect. Meeting this challenge, this thesis responds by developing a novel framework around FPS resilience that tackles links and dynamics among food system components;

- Second (CH2), uncertainty has not been dealt with adequately in any of the vulnerability assessment literature, which poses the great risk of incorrect analysis about where vulnerability lies currently and even more so for future possible vulnerability. The FPS resilience framework developed in Chapter 2 has defined vulnerability to food insecurity as situated between two thresholds (c.f. Figure 2.6): (i) a 50% probability line, differentiating between the food secure and the vulnerable to food insecurity, and (ii) a predetermined food poverty line, i.e. FP1, FP2 or FP3, which separates the vulnerable from the food insecure over time. This thesis further contributes to research questions dealing with uncertainty by incorporating the food security pillar of stability along with the social resilience dimension which affects SSC, bands of tolerance and safety-nets;
- Third (CH3), is the difficulty of analysing interactions across scales, which are difficult to tease out but which may well be the source of much systemic vulnerability. This thesis answers this analytical challenge by demonstrating that the FPS resilience framework takes into account these systemic interactions across scales through Panarchy Theory, i.e. panarchical relationships between adaptive cycles at different scales; and
- Fourth (CH4), insufficient attention has been paid to equity and justice as key ingredients to prevent system vulnerability. This last point further supports the moral challenges described in the introduction and justifies the call for the pursuit

of food security through FPS sustainability as argued for in this thesis. Attention is also paid to equity and justice in Chapter 8 on policy. Research will show that answers lay with the concept of social cohesion to address panarchical relationships between adaptive cycles.

Bearing in mind the four analytical challenges CH1 through CH4, Eakin and Luers (2006) propose identifying and researching their suggested five research actions listed in Table 5.1. Of note, FPS are the unit of analysis in this thesis (EL1) while each FPS is represented by an adaptive cycle. Another characteristic supported from the outset of this thesis, is sustainability, a key characteristic of any cyclical food system design (Hill 1982). Unsustainable FPS undermine the welfare and dignity of FPS participants while persistence of food insecurity and vulnerability in its many shapes and forms are avoidable. This is the expression of harm in action EL2. Previous discussions around moral challenges was introduced in Chapter 1 while a proposal for achieving greater equity and justice is given in Chapter 8 through integrating social cohesion into the FPS resilience framework. FPS characteristics (EL3) have been elucidated across conceptual Chapters 2 and 3. These include: (1) the four resilience dimensions ascertained according to the rule of hand in relation to the four food security pillars; (2) the four pathological traps; (3) FPS wealth reliance on ecological, social and economic subsystems; (4) FPS diversity, i.e. diverse systems are better able to tolerate a wide range of conditions than simple systems; and (5) FPS connectivity, i.e. a way of assessing the capacity of the system to adapt to external forces.

Table 5.1 – Five proposed research actions posited by Eakin and Luers, with corresponding analytical responses of this research.

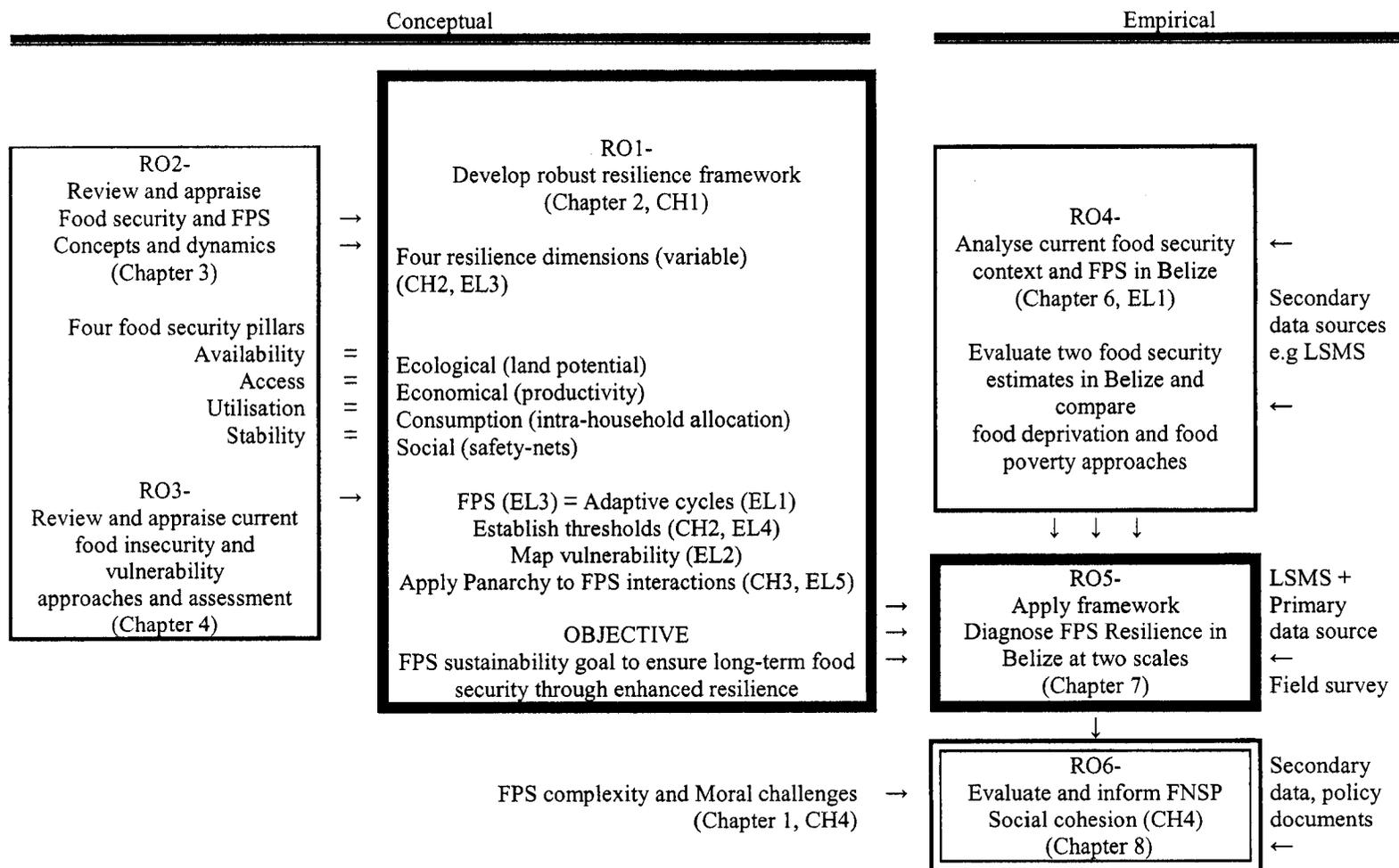
Five actions	Analytical responses
A proper unit of analysis (EL1)	<ul style="list-style-type: none"> • Belize selected as case study. • A proper unit of analysis is a FPS, represented by an adaptive cycle. • Two distinct adaptive cycles found: (i) a more modern food system with many commodities destined for export, and (ii) a domestic, more traditional-led FPS. • Empirical analysis in Chapters 6 and 7.
The meaning of harm for systems (EL2)	<ul style="list-style-type: none"> • Key characteristic of any cyclical food system design is sustainability. Untenable FPS undermine the welfare and dignity of FPS participants. Expression of harm viewed as the persistence of food insecurity and vulnerability in its many shapes and forms, e.g. pathological resilient traps. • Moral challenges (Chapter 1). • Social cohesion in equity and justice (Chapter 8).
System characteristics (EL3)	<ul style="list-style-type: none"> • FPS characteristics, concepts and dynamics reviewed and appraised (Chapters 2 and 3) • Rule of hand lead to four resilience dimensions corresponding to the four food security pillars. • Core resilience factors: wealth, diversity, connectivity
Thresholds of change and indicators (EL4)	<ul style="list-style-type: none"> • Two sets of thresholds: (i) food resilience thresholds (c.f. Figure 2.6) in relation to FPS steady-state conditions and bands of tolerance; and (ii) food security thresholds, i.e. a vulnerability probability line, and a selected food poverty line. • Consumption resilience significant in mapping adaptive cycles.
Interactions among drivers and components of the system (EL5)	<ul style="list-style-type: none"> • Emphasis on dynamic relationships essential to resilience theory. • Adaptive cycle looping nature and four phases. • Hierarchical confinement and panarchical relationships between adaptive cycles, e.g. memory and revolt (c.f. Figure 2.3). • Conservation phase of most elevated adaptive cycle key.

FPS: Food provision systems; EL: Five actions to meet all four analytical challenges (CH) (Eakin and Luers 2006).

As for the indicators and thresholds (EL4), the FPS resilience framework specifies a set of food resilience thresholds (c.f. Figure 2.6) in regards to wealth, connectivity and adaptive cycles, tracking FPS steady-state conditions and bands of tolerance. The framework also relies on two food security thresholds, a probability line and a selected food poverty line, which differentiate adaptive cycles and FPS participants to expose their respective food security status, either food secure, vulnerable or food insecure. Lastly, consumption resilience is particularly significant in assessing food security status. Regarding the final action posited by Eakin and Luers (EL5), the FPS resilience framework has given emphasis from the outset to the dynamic relationships of FPS components as well as between FPS and adaptive cycles. Essential to resilience theory is the explanation of such interactions. They described a FPS's dynamic, looping nature, the four phases of the adaptive cycle, as well as hierarchal confinement and panarchical relationships between adaptive cycles, e.g. memory and revolt (c.f. Figure 2.3).

The four analytical challenges (CH) and five actions (EL) are integrated into the thesis' analytical research framework presented in Table 5.2. The analytical framework shows a division of the research into conceptual and empirical segments. Each of the segment's three research objectives (RO) in Chapter 1, along with a description and their corresponding chapter numbers, are aligned to demonstrate ties between them to show not only how the research objectives are addressed, but match their corresponding analytical challenge (CH) and research actions (EL). In addition, in

Table 5.2 - Research and Analytical Framework.



RO: Research objectives from Chapter1; CH: Eakin and Luers' four analytical challenges; EL: Eakin and Luers' five recommendations to meet the four analytical challenges, i.e. CH; FPS: Food provision systems; FNSP: Belizean Food and Nutrition Security Policy.

the last column of the empirical segment, the data sources are placed to indicate where the data sources are used for analysis. Lastly, by following the arrows, the framework puts forward a sequence by linking the conceptual and empirical analysis to arrive at the FPS sustainability goal of achieving long-term food security in Belize through enhanced resilience, integration of social cohesion into the FPS resilience framework, and a more proficient food and nutrition security policy. The remaining subsections of this chapter further detail the units of analysis, data sources used, and field survey methods employed in Belize.

5.2 Units and Scale of Analysis

Food security analyses usually focus on the situation within countries at the national scale (FAO 2002). A country suffering from pressing issues pertaining to food security today has to do with food systems, encompassing a range of economic, environmental and social features that are undergoing rapid change (Maxwell and Slater 2004, Lang and Heasman 2004). Such rapid changes are occurring in Belize.

Belize was selected as the case study for this thesis research for several reasons. Food production in Belize exceeds national demand yet, as Chapter 6 will show, food insecurity in parts of the country reaches levels over 53%, with stunting over 18%, while many ethnic minorities demonstrate food poverty in several forms. Conversely, child obesity is on the rise. While agriculture, fisheries and the natural resource sectors continue to be major contributors to the economy and employment, these sectors are

highly susceptible, just as Belizeans are vulnerable, to extreme weather events such as hurricanes and tropical storms. Increased awareness among Belizeans of environmental concerns has risen recently, further rendering the FPS resilient with greater consciousness of losses in ecological wealth (GoB 2002). Additionally, the country's trade preferential treatment for selected export crops will end shortly, generally by 2009, and will greatly affect these key export commodities and crops including bananas, citrus and sugar. Other agents of change impacting the Belizean FPS include current macro-economic conditions, household financial difficulties, and natural hazards. Additionally, high transportation costs, low local storage capacity and higher post-harvest losses are affecting both food access and markets. Lastly, a greater number of Belizeans are eating out, unheard of nearly a decade ago, raising additional food safety concerns.

This suggests Belize's FPS is continuously exposed to evolving threats, and is having difficulty in reaching sustainability, maintaining FPS properties and services. Belize's FPS is also characterised, as Chapters 6 and 7 will demonstrate, by two distinct adaptive cycles, a more modern food export-oriented system, and a domestic, more traditional-led FPS. This lends itself well to the application of the FPS resilience framework and panarchical relationships developed in Chapter 2. In addition, Belize launched in 2001, a National Food and Nutrition Security Policy (FNSP) and Commission to monitor food security and nutrition, manage related federal programs and actions, and submit findings and recommendations to Cabinet. The realisation of the FNSP and Commission demonstrates strong awareness and desire in tackling food insecurity at a country level.

Finally, the presence of the Commission offered a great opportunity for in-country collaboration to conduct this research.

5.2.1 Description and Selection of Belizean FPS for Study

Belize boasts a spectrum of FPS. There are five main FPS distinguished by separate producer groups (GoB 2003): the first two labour-intensive FPS are (1) traditional local farmers who practice shifting cultivation, and (2) small producers who have access to mechanisation. They differ by agricultural practices, productivity, use of technology, and by crop production for own consumption and destined for domestic markets, and are represented by separate sets of adaptive cycles. The next two producer groups are characterised as more capital-intensive and are composed of (3) small and (4) large producers and fishers who produce commodities mainly for export. The adaptive cycles representative of these more heavily capital-intensive FPS are distinct from groups (1) and (2). For instance, a substantial part of the land area, including forest, savannah and arable land, is held by large landowners in groups (3) and (4) with over 20ha destined for export-oriented plantations; while small farms have a mean of around 8 ha (GoB 2003). Data from national food balance sheets (FAO 2006) show the country is self-sufficient in rice, beans and maize, although inexpensive imports for all three crops from Mexico and Guatemala have caused economic difficulties for smaller local producers struggling to compete (GoB 2003). The final distinctive FPS in Belize is the adaptive cycles made up of Mennonite communities (5), with holdings of up to 200 ha in central and north-western Belize. They are major producers of maize, poultry and dairy goods, among other commodities, and practice highly capital-intensive agriculture with yields similar to those

found in developed countries. These communities are self-sufficient in food and are major marketers of dairy products in Belize. Their land holdings and agricultural intensification practices differ entirely with the other four Belizean FPS. They have been given freedom and independence to manage their lands for the last sixty years and do not participate directly in national FPS for export nor in national food policies.

With regards to the selection of Belizean food provision systems under study, this thesis addresses the first recommended research action (EL1) by establishing FPS as the unit of analysis, with each Belizean FPS represented by a distinctive set of adaptive cycles. Scale is an additional criterion as the second of the three purposes of this thesis, c.f. Chapter 1, is to appraise current food security levels in Belize then apply the FPS resilience framework (EL3, EL4, EL5) at both a national and sub-national level. The choice then becomes a comparison of a minimum of two sets of adaptive cycles at alternative scales where food security is at risk of harm and degradation (EL2), with each potential set of adaptive cycles characteristic of the five particular segments of the Belizean FPS.

Four of the five FPS meet the selection criteria and may be chosen for this study. The fifth or Mennonite FPS was not retained as their FPS are fully developed, their adaptive cycles functional and self-sufficient, and their food security levels unimpaired. As food insecurity is prevalent elsewhere in Belize across the remaining FPS, this fifth FPS lies beyond the scope of this research. However, their success provides a good example of what could be achieved in the Belizean context. Still, the thesis does not draw on it as Belize's dominant paradigm of national wealth creation through international trade

overlooks domestic agriculture, i.e. groups 1, 2, and 5. Field research in Belize confirmed the results of the selection process as the country's national FPS is characterised by the following two major distinctive sets of adaptive cycles:

- (i) a wealthy and highly connected modern national capital-intensive FPS with most commodities destined for export, represented by groups (3) and (4);
- (ii) a domestic, more traditionally-led FPS, made up of groups (1) and (2) often situated at the sub-national scale, particularly in Toledo District; and
- as a result, both major Belizean FPS have been selected for analysis in this thesis and will be named the export-oriented FPS and domestic traditionally-led agriculture FPS.

As this thesis pays particular attention to food security, the remainder of this section provides a more detailed review of the domestic traditionally-led FPS where most of the severest forms food insecurity are found in Belize. The traditional producer group (group 1) practices milpa agriculture for producing staples, e.g. maize and beans, a form of subsistence farming using slash and burn practices and shifting cultivation, which require low inputs but offer low productivity. However, rice is mostly produced as a cash crop, and together with any surplus of maize and beans, is destined for national markets and Belizean ethnic diets. A sizeable proportion of farmers still employ shifting cultivation as part of milpa agriculture. These traditional practices are centered in the south of the country and around the numerous communities that have sprung up as resettlement sites for Central American refugees. Indeed, Toledo District particularly draws the largest

number of small and traditional farmers together in the country. In these areas there is a pressing demand for good agricultural land and quality ecological wealth. Traditional farmer populations are increasing in Belize, ensuing in shorter fallow periods and resulting in further degradation of ecological wealth, e.g. with losses in soil fertility and soil structure (FAO 2003c). This modern land limitation of smallholders continues the historical trend currently favouring the export sector. Though, as milpa practices wane, FPS connectivity increases with a greater concentration of farms converting to mechanised agriculture (group 2) with a commensurate consolidation of small farms into larger holdings, i.e. group 3 (FAO 2003c). While staple FPS from traditional practices are in decline, still more than half of all farmers in Belize are considered milpa farmers, whereas 60% of all rice and maize farmers are considered milpa farmers. A large portion of small farmers also produce sugarcane and citrus. In fact, about 92% of all citrus growers are small farmers (using less than 8 ha) producing less than 20% of total production, while about 98% of all sugarcane producers are small farmers producing the bulk of the crop.

5.3 Data Sources and Methods

Both qualitative and quantitative data were pulled together for this research from original (primary) data as well as existing (secondary) data. Table 5.3 categorises the data sources and research used and collected in this thesis to address the analytical research objectives RO4 to RO6 of the empirical segment of the thesis. As FPS must be applied in a place-based context (Fine 2002), and as data of food systems are most commonly collected by interviewing and observing particular populations (Hartog 1995), qualitative food

security and food system data were collected in Belize through key informant interviews. Additional contacts were made in-country to obtain necessary secondary data, both qualitative and quantitative. The subsequent section details the semi-structured interview method and field survey conducted while in Belize.

Table 5.3 – Primary and secondary data sources employed in thesis research.

	Primary data (Original) RO5	Secondary data (Existing) RO4 and RO6
Qualitative	Semi-structured interviews: Field survey with key informants	Government policies and sectoral analysis, i.e. food and nutrition security, agriculture, fisheries and coastal zone management, aquaculture, economy, health, environment, natural resources, immigration, central bank, early warning system and tourism. International organisation country and regional studies, i.e. PAHO, FAO, UNDP, IICA, INCAP Local academic studies and research, i.e. University of Belize, Central Farm Research Station, CARDI
Quantitative		National Food Balance Sheets (FAO 2006) Poverty Assessment (CSO 2004) Living Standard Measurement Survey (CSO 2002) Population census (CSO) Environmental Conditions, and Agricultural Market information (Ministry of Agriculture)

RO: Research objectives addressed by data source.

5.3.1 Primary Data - Interviews and Field Survey

Funding from the Inter-American Institute for the Cooperation on Agriculture (IICA) was used for fieldwork from November 2004 to January 2005 to ascertain which components of Belize's FPS are at risk to change, and how other factors such as trade and natural hazards either augment or lessen FPS resilience to such change. In addition, the focus

was to assess, through interviews, the capacity of Belize's FNSP to address multiple stressors on FPS. The work approached the identified problem from both a national perspective and sub-national (district) perspective. The fieldwork in Belize was also used as a means to understand the strengths and weaknesses of both major Belizean FPS, as determined by the selection process in Section 5.2.1, relative to existing threats, shocks and disruptions, and their capacity to provide resilience against change.

Semi-structured interviews with key informants were used to collect data to achieve analytical research objective RO5. The questionnaire presented in Appendix A provided a framework for the interviews. The interview topics were divided beforehand into three categories: (1) current food security and FPS context, (2) resilience dimensions, and (3) emerging issues and future trends. The topics concerned: (1) opinions, perceived prevalence, determinants, and potential secondary data sources, and (2) policy gaps, and practical problems accompanying food security research, to assess FPS resilience and food security and nutritional status of Belizeans. The qualitative data thus provided background information as well as issues of policy and evaluations, such as informants' perceptions of a particular program or unexpected ways in which a program or policy affected food security in Belize. Lastly, the interviews also provided contacts and references of secondary data for addressing research objectives RO4, for the analysis of Belizean food security and FPS, and RO6, on the nation's food security and nutrition policy, and on social cohesion.

Before starting the interview, participants were asked for permission to record their names for this research. The names and affiliation of the respondents are given in Appendix B. Interim analysis (Pope et al. 2000), in which field data already gathered, are analysed and shape the ongoing data collection, was used to omit, refine or add questions during the interview process and secondary data gathering post-interview. The interviewees were selected based on their experience with food security and relevant fields representing a range of food security expertise, sectors and backgrounds. The number of participants was determined: (1) on the basis of membership on the National Food and Nutrition Security Commission, (2) on additional contacts and references provided in interviews with Commission members, and (3) according to the principle of saturation (Bowling 1997), i.e. when interviewees supplied no new information, as a sufficient sample size was deemed to be reached and the primary data collection stopped (Glaser and Straus 1967). Over twenty-five qualitative interviews were conducted during fieldwork³ when the principle of saturation was achieved. Overall, interviewees (n=25) came from:

- The GoB (n=15, by department: Agriculture 5 (extension, institutions, markets/trade, policy and production), BAHA (food safety) 1, Environment 1, Fisheries 2, Health 1, Human Development 1, NEMO (emergencies) 1, Standards 1 and Statistics (LSMS) 2;

³ Less formal interviews and exchanges with additional respondents such as independent tour and lodging operators, the Ministry of Immigration, workers at Central Farm (Research and Extension), the Central Bank, traders and small-scale farmers, researchers at the University of Belize (Central Campus), and Taiwanese shop-keepers.

- Civil society (n=2, a well-recognised national food security specialist, and an indigenous association representative from Toledo District);
- International organisation (n=6, one respondent each from CARICOM, CATIE, FAO, IICA, PAHO and UNDP);
- Academia (n=1, a Caribbean climate change specialist);
- Industry (n=1, a Mennonite farmer from Spanish Lookout); and
- of the 25 respondents, 4 were women.

The results from the surveys of key informants, depicting multiple factors of change driving food security in Belize, are summarised in Appendices C, D and E. Although the principle of saturation did apply, if the mix of respondents varied to include key additional private sector and civil society contacts, or women for instance, it is plausible the results would vary, a limitation acknowledged in this analysis. Findings in Appendices C, D, and E represent a summary of the responses regarding concerns, stressors, opportunities and reactions raised by key informants at sub-national (district), national and regional scales. For each of these scales, factors have been assembled within the first three corresponding food security pillar: availability, access and utilisation, along with current and potential responses respectively in the last column. This primary data predominantly feeds into the thesis' second empirical research objective RO5 in Table 5.2 on the application of the FPS resilience framework.

To complete research objective RO5, further examination of the findings in Appendices C, D and E, lead to an analysis of the strengths and weaknesses of both major Belizean

FPS, by resilience dimension and respective food security pillar, the results of which are displayed in Table 7.1. It not only captures the results from field research but reflects the responses from the semi-structured surveys of key informants broken down to discern the Belizean FPS resilience appraisal of both major sets of adaptive cycles explored in this thesis. The levels of complexity of the Belizean FPS stand out superbly when examining the table.

5.3.2 Secondary Data Sources

In choosing data, measures and possible indicators, the search to maximize the quality of the information, and its benefit for research, takes into account the costs of collecting, processing, and analysing that information. In deciding what available research should be included, several considerations should be kept in mind: relevance, credibility, comparability, accuracy, time period, and information use. Relevant data and credible sources, i.e. objective, accurate, and universally understood data, on Belizean FPS and the country's current food security situation, were identified during the semi-structured interview process while in Belize, and collected thereafter.

These additional secondary data sources were gathered and references contacted after each interview. Publications, policy briefs and sectoral analyses were collected in various governmental departments, from the Food and Nutrition Security Commission, to the Ministries of Agriculture, Fisheries and Coastal Zone Management (including aquaculture), Economy and the Central Bank, Health, Environment, Natural Resources, Immigration, Tourism, and the National Emergency Management Organisation, i.e.

NEMO (similar to early warning system). Additional data sources, and country and regional studies were obtained from international organisations, i.e. FAO, IICA, INCAP, PAHO, UNDP and UNICEF. Lastly, local academic studies, research and grey matter were gathered from the University of Belize, the Central Farm Research Station, and the Caribbean Agricultural Research Development Institute (CARDI).

Particularly useful are the FAO's National Food Balance Sheets (NFSB, FAO 2006), introduced in Chapter 4. This specialized food deprivation method and data source will receive detailed attention in Chapter 6 and will be compared to a food poverty method and national food security statistics assembled, examined and published by the GoB. Both methods will be reviewed, appraised and compared, a comparison which will further illustrate the variety of methods used to measure food security through alternative instruments presented in Chapter 4.

5.3.3 Living Standard Measurement Survey

A very significant data source frequently highlighted during the interviews was the country's latest Poverty Assessment (CSO 2004) based upon the 2002 Living Standard Measurement Survey (LSMS). The assessment supports a major part of the explanatory research results for the entire empirical segment of this thesis. As poverty analysis concentrates on measuring the socio-economic status, wealth, and inequality, this poverty assessment is of particular significance to this thesis, as it corroborates much of the field research accomplished in Belize. The rest of this section introduces the main LSMS

elements as it is of particular relevance to the first empirical research objective RO4 (Table 5.2).

The LSMS is an instrument for measuring and understanding poverty in developing countries, developed and used by the World Bank (Grosh and Glewwe 1996). LSMS surveys provide data on most aspects of household welfare, i.e. consumption, income from activities in the labour market, agriculture, asset ownership, migration, health, education, nutrition, fertility, and anthropometrics. The surveys also assist in understanding household economic decisions and the effects of social and economic policies. The use of LSMS data in food security assessments helps to ensure that the development of FPS participants' efforts to reduce poverty can be guided by quantitative information on levels, causes, and consequences of food insecurity (i.e. harm, EL2), and food poverty in particular.

Three different kinds of questionnaires are normally used. The first is the household questionnaire, which collects detailed information on individuals, i.e. household members, along with welfare measurements determined by consumption. The second is the community characteristics questionnaire, in which key community leaders and groups are asked about (1) community infrastructure, i.e. local infrastructure, roads, the sources of fuel and water, the availability of electricity, means of communication; along with (2) local agricultural conditions and practices. Third is the price questionnaire, in which market vendors are asked about prices of commonly purchased goods. Lastly, a fourth type of questionnaire, used on occasion, collects information on schools and health

facilities. The 2002 Belizean Poverty Assessment (CSO 2004) had three components, a LSMS, pre- and post-survey focus group discussions, and an institutional assessment of relevant government departments and non-governmental organizations. The LSMS covered 1 700 households and is nationally representative. The LSMS questionnaires comprised sections on (1) household expenditure on food and non-food items, (2) housing characteristics, (3) a households' knowledge of, and participation in, community projects and, (4) households experiencing financial difficulties and their coping strategies. Data from these sections is incorporated and presented in the empirical research of this thesis. Additional LSMS data used in this research include basic demographic, health and education information on individuals five years or older as well as information on economic activities of those 14 years or older. Only the demographic and health information, e.g. anthropometrics, of children under five years of age were included in the LSMS. Of particular relevance to the FPS resilience framework, indicators of adult equivalents estimating the minimum food requirements were established for nine different age groups disaggregated by sex of each group while the actual cost of the food basket was used as the indigent line, c.f. the FP3 food poverty line in Figure 2.6 (see Table 2.4 for a definition of the indigent).

Chapter 6 – Geography and Food Security Assessments of Belize

This chapter's research objective (RO4) is to describe and appraise current food systems and analyse the food security situation in Belize. This vastly descriptive chapter begins with a comprehensive narrative of Belize's people, their history, followed by a depiction of Belize's physical geography, as well as an examination of the country's agricultural and other primary sectors. Subsequently, this chapter culminates with an assessment of food security in Belize. The assessment will uncover two distinct approaches used to measure food security in Belize. The first, employed by FAO, is based upon food deprivation, while the second, applied by the Government of Belize, uses a food poverty approach. The review and appraisal will serve to illustrate the short-comings of both approaches in measuring food security compared to the FPS resilience approach. Based on these findings, Chapter 7 responds to this analytical gap by applying the FPS resilience conceptual framework to different FPS adaptive cycles in Belize, searching for potential pathological traps and panarchical relationships in an effort to ensure food security as FPS are faced with incessant change.

6.1 Human Geography of Belize

6.1.1 Its People

Belize is a multicultural nation as a result of successive waves of immigration over the course of its history. Early immigrants included British colonists, African slaves from the West Indies, Maya and *Mestizo* (mixed-race) refugees from Central America, indentured labourers from India, and economic migrants from the Middle East and China. Belize has

a very rich and diverse ethnic population composed of Creoles, East Indians, Mennonites, Mestizos, Garifunas, and Ketchi, Mopan and Yucatec Maya. The country is experiencing increasing immigration flows from Central America and Taiwan/East Asia. Foreign-born citizens were estimated at over 14% for 2002. Central Statistical Office (CSO 2004) statistics show 53% of the population as Mestizo, whereas 25% are Creole. Mestizos are increasing as a percentage of the population, in part owing to immigration from neighbouring countries, conversely creating a decline in the proportion of the population that is Creole. Maya (10%) and Garifuna (7%) are the two other main ethnic groups. The Garifuna, descendants of Amerindians and African slaves, have a particularly well-documented history of forced and voluntary migration, which includes migration to Belize in the early 1800s (Gonzalez 1988). And lastly, Mennonites from Mexico settled in Belize in large communities in the 1950s.

Current population figures from the 2005 mid-year CSO census data sit at 291 800, up from 211 000 in 1994, while the projected total population for 2030 is estimated at 386 000 (U.N. 2004). In fact, it is estimated that one to two million people occupied Belize in the classic Maya period as much of the land that is now forest was used for agriculture and settlements (Jolly and McRae 2003). In 2002, children and adolescents less than 18 years old accounted for almost one-half of the population, whereas only 4% are aged 65 years or older. The population is spread out half in rural areas and half in urban areas and towns. Around one-half of the rural population live in large villages in the north, whereas inland areas in the centre and the south are sparsely inhabited. Most of the population live

on the coast, including almost one-half of the population in Belize City and its surrounding districts. Belize City's population tallies over 60 800 inhabitants.

6.1.2 Migration

Salient to Belizean FPS resilience, migration follows complex and diverse patterns and particularly affects social and economic wealth. External influences, i.e. restrictive immigration legislation, unstable prices for primary sector exports; combined with local constraints, i.e. land shortages and high rates of unemployment; produce constant shifting patterns of international mobility in the Caribbean (Babcock and Conway 2000). Belizean international migration is typical of Caribbean emigration in that rates of movement are high and mobility patterns complex. What is unusual about migration in the Belizean setting is the presence of high rates of immigration as well as emigration.

From Honduras, Guatemala, and El Salvador, immigrants to Belize tend to find employment in agriculture and engage in subsistence farming. Immigration of 'foreigners' is thought to strain the limited social wealth in Belize. For instance, many banana ventures since 1980 have relied on Central Americans who, uprooted by war and poverty, fled to Belize. These economic immigrants and political refugees comprise over 92% of Belize's banana workforce (Moberg 1997). Because these new immigrants are willing to work for low wages, they have displaced native Belizeans in some of the seasonal agricultural industries not without causing resentment and racial tensions (Moberg 1993). The presumption that Belizeans are averse to agricultural labour rationalises their displacement from the banana industry. Tensions are further galvanised

by Belizean growers who rely on effective economic strategies such as reserving the lowest-paying farm jobs for immigrants who most fear deportation (Crichlow 2003, Moberg 1997).

6.1.3 Belize's History Relevant to Present Food Security

Underdevelopment in Belize is rooted in British colonial practices (Babcock and Conway 2000). Formerly British Honduras, Belize's colonial existence was mainly predicated on the extraction of forestry products using slave and indentured labour under the control of a European minority. Consolidations of land holdings by foreign investors lead to increasing system connectivity, and a higher-level and broader adaptive cycle (practices still on-going today within FPS). Such consolidation began during centuries of hardwood extraction, transforming ecological wealth, and was reinforced by constraining social wealth through (1) land tenure practices, designed to restrict lower-level adaptive cycles and (2) local economic wealth, such as limiting small-holdings; and guaranteeing a ready supply of low-wage labour (adapted from Moberg 1993). The historical relationship between export sectors and local economies sets the foundations for the current panarchical relationships, hierarchies and segregation between their higher- and lower-level adaptive cycles in Belize.

Primary reliance of Belize's economic growth on the export of forest resources dominated the colony's economy up through the 1940s. Economic wealth diversification in the form of intensified sugar, citrus and banana cultivation did not occur until the post-war period of the 1950s. To this day, as field research has uncovered, the small size of the

Belizean economy, and the reliance on these three key export commodities, the dependency on a small number of trading partners, i.e. U.S.A. and the United Kingdom, and on imported FPS goods and services, have perpetuated FPS vulnerability to food insecurity. Similar research findings by Babcock and Conway (2000) further corroborate these results.

Early on, devastation of indigenous societies between the 15th and 18th centuries in the Caribbean region was common (Macpherson 2003). Their marginalisation in coastal regions including Belize, produced radically new societies as well as colonial regimes. In sum, Belize became a low-wage largely non-industrial economy controlled by foreign corporations, with the colony dominated by timber extraction. In the 20th century, poverty sparked several major public disturbances in the Caribbean region. In the 1930s, the appalling living conditions of workers, and plantation workers in particular, culminated in the 1938 disturbance across the Caribbean which the West India Royal (Moyne) Commission Report (1945) was mandated to investigate. The Commission confirmed the high levels of impoverishment that it was confronted with during the investigations. This report also spawned sociological models, as well as directly affected social policy and political outcomes in the region. The report served an important part in subsequent FPS policies and strategies by which various Caribbean countries altered land use by attempting to increase food availability.

With regards to FPS services from the 1930s onward, paid labour and petty food production, e.g. produce and baked goods, were central to the livelihoods of working

class women, many of whom were heads of households, along with domestic service or subsistence farming combined with seasonal citrus wage labour (Macpherson 2003). However, poverty and malnutrition remained critical. From 1941, clinics provided poor mothers with powdered milk during wartime price inflation, and by 1944 the approach had cut Belize City's clinic babies' mortality rate to 15 percent of the colony's average (British Honduras Medical Report 1944, in Macpherson 2003). After the Second World War, vocational education in the trades and agriculture was suggested for boys. Consequently, given the limited employment opportunities at the time, women were offered classes in infant welfare, nutrition and cookery. The acting political institutions were thus sending the message that most Belizeans were somehow to blame for their own poverty, while gendered differences advanced FPS vulnerability to food insecurity (adapted from Macpherson 2003) a precursor to current aspects of consumption resilience, intra-household allocation and food utilisation.

6.2 The Physical Geography of Belize

Belize is located on the eastern Caribbean coast of Central America, with Mexico to the north and Guatemala to the west and south. There are hundreds of cayes and coral reefs located in its inner coastal waters. Total land area measures 22 963km². The country has six administrative districts: Corozal and Orange Walk in the North; Cayo in the centre West; Belize District, centre East; with Stann Creek and Toledo Districts in the South (Figures 6.1, 6.2). The country boasts two major ecosystems, a lowland and an upland ecosystem set apart amid ecosystems 400m above sea-level or more (Jolly and MacRae 2003).

The lowlands consist of a large mix of ecosystems: (1) low coastal plains in the north and south (coastal ecosystems), with mangrove swamps, coastal and sea-grass lagoons, and littoral forests; (2) fresh water wetland ecosystems, i.e. herbaceous swamps, seasonally flooded savannas and marsh forests; and (3) river ecosystems, (4) pine ridge ecosystems and (5) lowland broadleaf forests. The country also hosts upland ecosystems with the Mountain Pine Ridge in the west ranging from 305 to 914m, as well as broadleaf forests. The Maya Mountains stand in the south, taking up much of the country's surface. The highest point is Victoria Peak at 1128m. The climate is sub-tropical, tempered by trade winds. Mean daily temperatures in coastal areas range from 10°C to about 35°C. Average annual rainfall varies from 1 295mm in the north to 4 445mm in the extreme south. There are two seasons in Belize: a rainy season, from June to November, and a dry season for the remainder of the year usually strongest from February to May, with an occasional dry spell in August. Hurricanes and tropical storms may impact Belize anytime during the rainy season, with most arriving in mid-September to mid-October. Historically, the country is affected on average by one hurricane every three years (NEMO 2005).

Lastly, three-quarters to four-fifths of the land is forested and under natural vegetation cover (FAO 2003c), of which up to half are recognised as protected areas, both public and private, due to strong conservation efforts (CSO 2000). About 38% of the statutory protected areas are dedicated to biodiversity conservation, education, visitation, and research while the rest are located within areas allowing for managed extraction of resources including timber (FAO 2003c).

Figure 6.1 – General Map of Belize (FAO 1998).

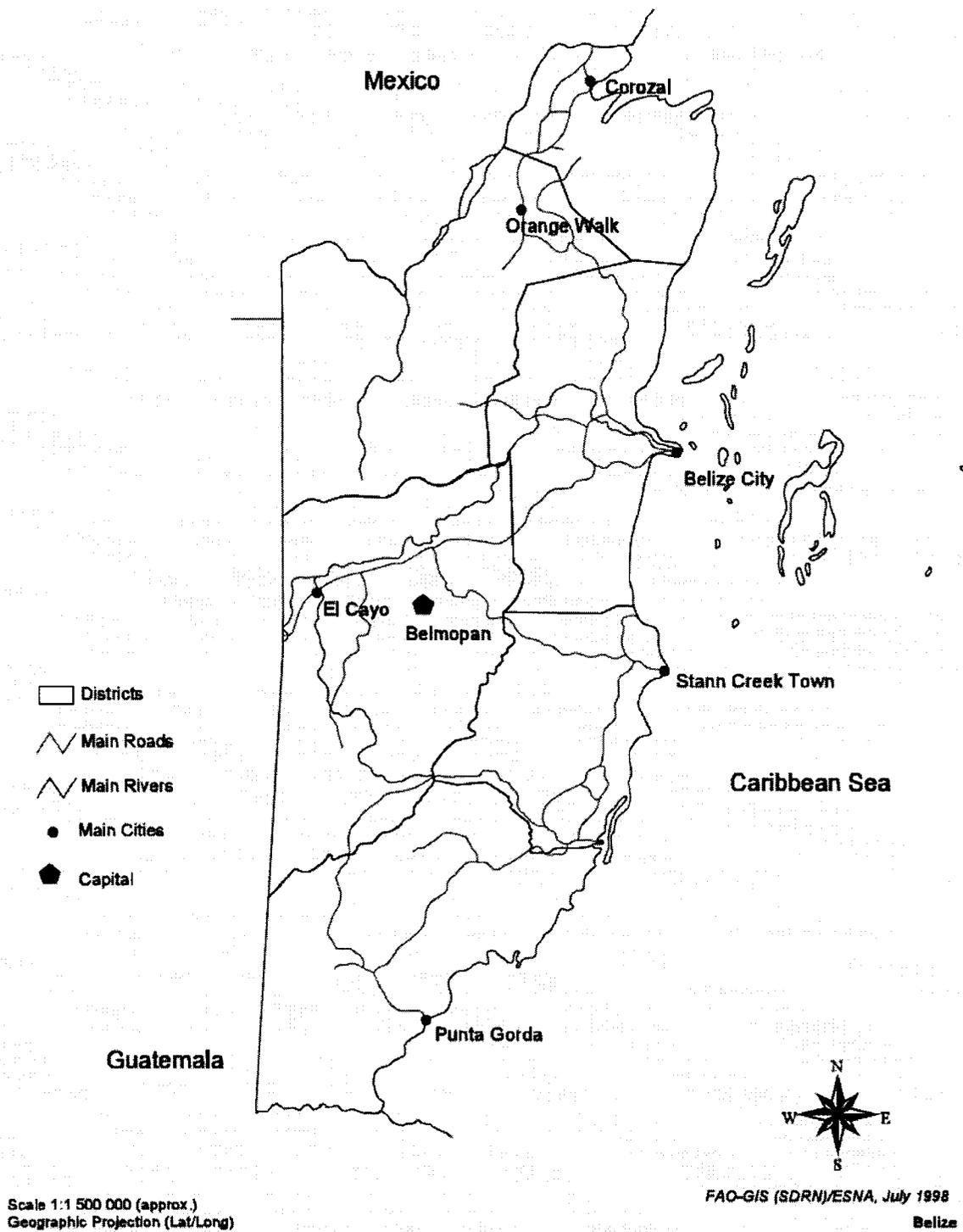
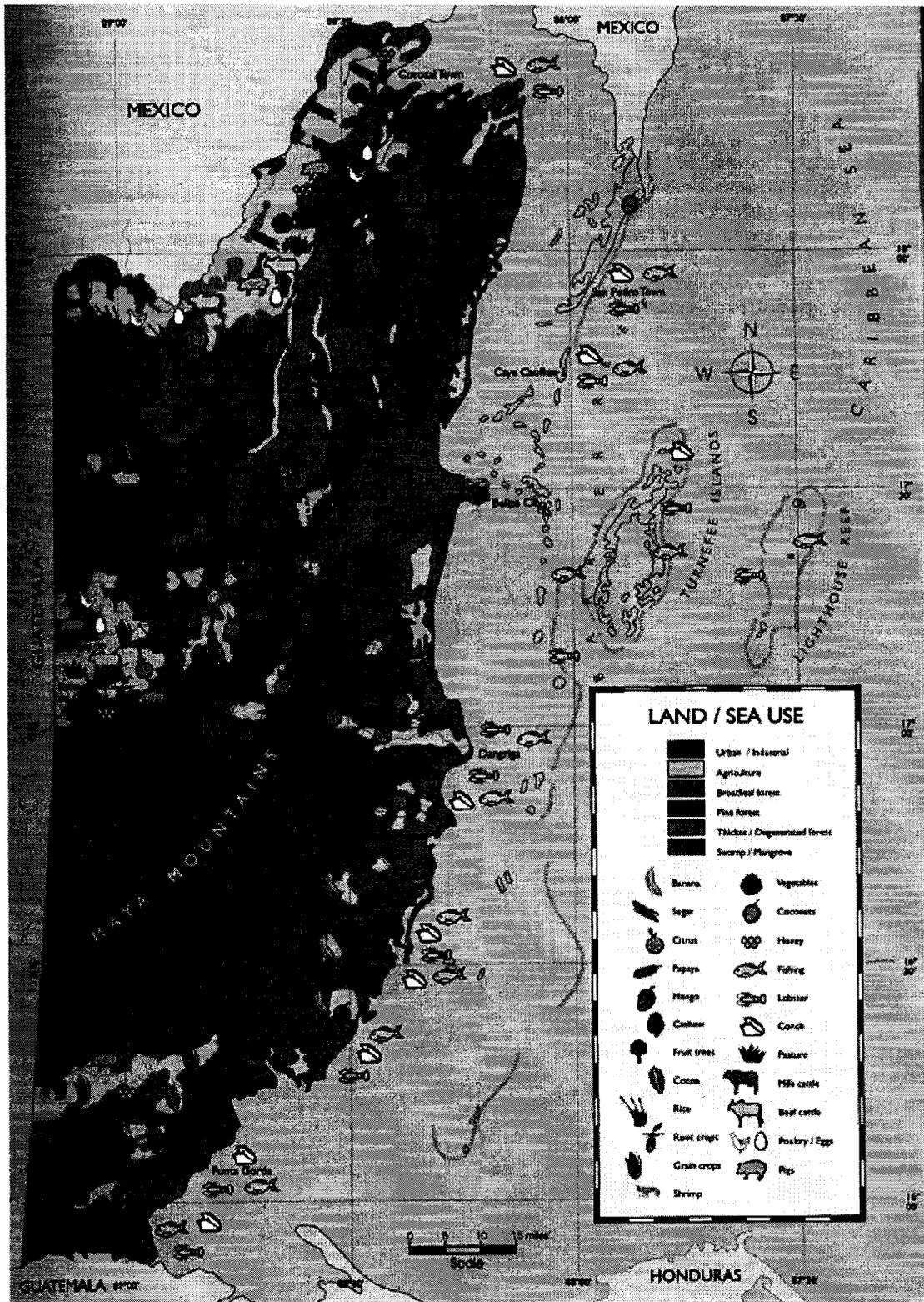


Figure 6.2 - Map of Land and Sea Use (Cubola Productions 2002).



6.3 Economic Sectors

6.3.1 Agriculture

6.3.1.1 Land Use

The summary of land cover and use in Belize given in Table 6.1, shows total agricultural land cover at 10%. A drawback of this summary are the inaccuracies in land cover figures of current Belizean FPS as the latest available data source dates back to the 1989-92 period. However, analysis on these measurements, show how land availability for agriculture development is limited, in spite of the country's small population base. For instance, 44% of all the land consists mostly of the steep slopes of the Maya mountains, suited for forest cover. Another 20% of the land has very poor drainage, is shallow, subject to drought, and is also suited for forestry. These two types of unsuitable land for agriculture development (Grades 4 and 5, Table 6.2) represent 64% of all land in Belize (GoB 2004). Of the remaining 36% of the land, 16% in absolute terms is suitable for agriculture development and production with minimal additional inputs to enhance soil properties (Grades 1 and 2 soils, Table 6.2). These lands are mainly used for export crops, i.e. sugarcane, banana, citrus, and pasture development. The 20% of the land remaining is marginal for agriculture (Grade 3, Table 6.2) requiring proper management to overcome poor drainage, compaction and shallow soils. For example, citrus and banana production may be found under Grades 1 and 2, while cattle ranching can be found in Grade 3. All grades may support shrimp farming and aquaculture, as well as medicinal plants, mangroves, and clay for handcrafts, though they are particularly found under Grades 4 and 5. Currently, about a third of the 16% of lands under Grades 1 and 2 are dedicated to agricultural production while the rest is held as undeveloped land by the

Table 6.1 – Summary of Land Cover and Use in Belize (1989-1992) (FAO 2003c).

Class	Subclass	Percent of total	Area in hectares
Urban Areas		0.6	6,362
	Built Up	0.262	
	Non-built up	0.122	
Agricultural Land		16.8	215,966
	Herbaceous Crops		
	Annual Crops -mechanized (with pasture)	1.048	
	Annual crops – non mechanized (with ridge and thicket)	0.901	
	(with Herbaceous and Scrub Secondary regrowth)	0.165	
	Bananas	0.184	
	Sugar-cane (with herbaceous and Scrub secondary regrowth)	0.085	
	2.943		
	0.072		
	Tree Crops		
	Citrus	0.599	
	Mango	0.076	
	Cocoa	0.008	
	Cashew	0.002	
	Shifting cultivation (milpa style) (with thicket)	1.71	
	0.209		
	Pasture		
	(with mechanized annual crops)	1.54	
	0.29		
	Clearing for farming	0.198	
	Shrimp farming / aquaculture	0.012	
Range Land		9.8	162,341
	Savannah (herbaceous, scrub or tree) (with thicket)	8.827	
	1.971		
Forest and other Wooded Areas		78.9	1,721,388
	Broadleaf Forest (including secondary)		
	(with thicket)	65.12	
	(with pine)	0.860	
	0.280		
	Open Broadleaf Forest (woodland)	0.552	
	Pine Forest	2.54	
	Open Pine Forest	0.34	
	Thicket and other degenerated Broadleaf Forest	3.89	
	Herbaceous and Scrub, secondary regrowth after farming or clearing	0.88	
	Bamboo and Riparian Vegetation	0.529	
	Coastal Strand Vegetation	0.114	
	Mangrove (Medium – Tall)	0.369	
	Mangrove (Dwarf)	1.077	
	Saline swamp vegetation with palm-trees and mangrove	1.269	
	Marsh Swamp	1.928	
Unproductive Land		1.8	89,878
	Bare Land	0.0351	
	Water Bodies	1.800	
Totals		100.0	2,179,067

Table 6.2 – Agricultural land suitability by district and soil grade in Belize ('000ha).

Agricultural Land	Grade 1	Grade 2	Grade 3	Grade 4 & 5	Total
District	Suitable for Agriculture			Marginal/ Not Suitable	
Corozal	0	74.62	25.86	85.64	186.12
Orange Walk	0.64	121.88	155.59	185.89	464.00
Belize	17.37	26.37	66.98	320.36	431.08
Cayo	41.59	26.21	80.07	372.11	519.99
Stann Creek	12.78	18.66	19.28	204.87	255.59
Toledo	26.62	11.97	100.78	302.33	441.71
Total	99.01	279.72	448.56	1 471.19	2 298.47

Source: FAO (2003c), CSO (1991).

government and private landowners (FAO 2003c). Figure 6.2 also points out that most agriculture occurs in the fertile lowland along rivers and away from swamps. Figure 6.2, further shows the crops are concentrated in particular areas: sugar cane in the north, and citrus and bananas in the south, as access to respective processing plants are also nearby. More specifically, Figure 6.2 reveals permanent crops, grain crops and sugarcane predominate in the north (Orange Walk and Corozal Districts), with a mix of grain, livestock and produce in Belize District. Cayo District in the west is quite important due to the presence of the Mennonites in Spanish Lookout north of Central Farm. Through imported inputs and modern technologies, these large Mennonite producers in western Belize (Cayo and part of Orange Walk Districts), produce maize, poultry, pork, dairy, eggs and beef output, staple commodities for which Belize has achieved a significant level of self-sufficiency. To the south, citrus, bananas and aquaculture are mainly farmed in the Stann Creek, along the valley and the coast. The most heavily cultivated lands lie along the Río Hondo to the north, the Belize River Valley Plains to the west, and along the southern foothills of the Maya Mountains. According to field research data compiled

from the Belizean Department of Agriculture, the main agricultural export crops are sugarcane (cultivated in the two northern districts of Corozal and Orange Walk), citrus (grown principally in the Stann Creek district) and bananas (in Stann Creek and Toledo districts). Together they cover 29%⁴, 6% and 1% of the entire agricultural land class, respectively (Table 6.1). Most of the remaining agricultural land is devoted to traditional and non-traditional crops and pastures.

6.3.1.2 Agricultural Exports

Sugarcane accounts for about one-half of all arable land use, with production tied closely to preferential export quotas with U.S.A. and the EU. Sugar has traditionally been the country's most important export but the value has recently dropped below those for marine products and citrus concentrate (Table 6.3). As a result of lower than average production volumes and falling export prices, the processing and marketing company, Belize Sugar Industries (BSI), which is cooperatively owned, has been unable to pay dividends. An EU proposal to cut the price paid for sugar imports by 20% in 2006 and 2007, will, if carried out, greatly increase the difficulties already faced by the industry. To help boost production and export volumes, the management structure of the industry was reorganised in 2001 through the Sugar Industry Act. In the same year the quota system was suspended to allow increased production and BSI was given permission to grow its own cane. BSI also plans to increase revenue from cane production by building a US\$30m co-generation plant, using bagasse, i.e. cane waste, to generate electricity.

⁴ The figures are obtained from Table 6.1 by taking the percentage share of sugarcane, i.e. 2.943 over the percentage share of the total land class under agriculture which is 10.0, thus giving 29.43%.

Other export crops include organic cocoa, papaya, chilli peppers, vegetables and other tropical fruits. Papaya production and exports have substantively expanded in recent years (Table 6.3). The Ministry of Agriculture has also initiated projects for diversification into soybeans and cashews. Livestock rearing has also increased in recent years and the country has become self-sufficient in fresh meat and poultry. Beef on the hoof is exported to neighbouring Guatemala and Honduras, although processed meats continue to be imported, mainly from the US, to provide consumers with a greater variety of meats.

Table 6.3 – Annual major exports (in nominal \$BZ) for 1999 to 2003.

	1999	2000	2001	2002	2003
Marine products (m lb)	5.7 (55.6)	3.2 (70.4)	4.1 (66.4)	3.3 (70.4)	7.8 (110.2)
Sugar ('000 tonnes)	104.1 (86.6)	109.3 (74.4)	95.5 (59.4)	104.9 (66.0)	109.8 (73.8)
Molasses (m gallons)	- -	5.1 (0.3)	4.8 (1.6)	5.6 (2.7)	5.6 (2.5)
Bananas ('000 tonnes)	- -	63.7 (65.8)	50.1 (42.8)	41.8 (33.5)	74.9 (52.6)
Citrus concentrate (m gallons)	3.9 (54.9)	6.3 (108.7)	5.7 (84.5)	4.4 (67.4)	6.0 (78.7)
Sawn wood (m board ft)	- -	1.8 (4.6)	1.1 (2.7)	1.1 (2.6)	1.0 (3.6)
Papaya ('000 tonnes)	- -	5.2 (11.4)	6.25 (10.3)	11.1 (15.5)	16.5 (16.6)

Sources: Central Statistical Office; Central Bank of Belize, *Statistical Digest*.

6.3.1.3 Employment in Agriculture

Fifteen percent to 25% of the entire labour force in agriculture is comprised of temporary and migrant foreign workers. In fact, FAO (2003c) figures show that a quarter of the

entire employed population is engaged in agriculture and forestry activities, a decline from 30% of the employed population in 1991. The main industry in the urban areas is wholesale and retail sales, while agricultural production and processing are the main industries in the rural areas.

The agriculture industry is strongest in Toledo, Corozal and Stann Creek Districts. Sugar is the largest industry in Corozal District (28%) even though the factory is located in Orange Walk. Fishing and fish processing is strongest in Stann Creek accounting for 5% of the employed population. This district is home to most of the shrimp farms or aquaculture in Belize.

Most of the employed population (33%) is engaged in primary sector services, e.g. in agriculture and related industries. The rate of participation in the labour force is almost the same for men and women. Apart from primary sector services, men are mainly occupied as craft and related workers (19%) while others as agriculture, forestry and fishery workers (14% combined). Agriculture continues to form the foundation of the rural economy of Belize. At least 35% of GDP and 41% of total employment is directly dependent on agriculture, fisheries and forestry, while 90% of all manufacturing, which constitutes 17% of GDP and 12% of employment, is based on agricultural inputs from these three primary sectors, e.g. sugar, citrus concentrate, animal feed, agriculture chemicals, furniture, jams, jellies, chips, juices, milk, ice cream, and packaging.

6.3.1.4 Decreasing Investments and Access to Credit

Given the importance of agriculture to the Belizean economy, since the early 90s, however, state investments in agriculture have steadily declined. The proportion of the government's budgetary allocation (both recurrent and capital) to agriculture in 1990/91 was 3.5% while in 2002/2003, this allocation declined to less than 1.1%. Conversely, total commercial credit to agriculture increased as aquaculture in large part was responsible for more than 37% of the total increase (Myvett and Quintana 2002). In interviews with small farmers during field research for this thesis, they reported having lasting difficulties in obtaining financing for improvements through the government-owned Development Finance Corporation (DFC), regarding loans for agriculture while larger and export-oriented farms are being favoured. In response to these difficulties, the government had established the Small Farmers and Business Bank. Nonetheless, loans to agriculture, including aquaculture, have shown a decline in the proportion going to the agricultural sector, from 18% to 11% for commercial banks and from 40% to 13% for the DFC as loans continue to be targeted towards traditional export sectors, i.e. sugar, bananas and citrus. However, within the agriculture sector alone, commercial banks have also reduced their credit allocation to these traditional export crops from 81% to 69%, and from 64% to 39% for DFC; though most of this reallocation was channelled to the aquaculture industry with the loan rate going to non-traditional activities remaining stable.

6.3.2 Fisheries

Since the 1970s, the fisheries sector has progressively become an important contributor to the Belizean economy. Current national estimates show 1 300 fishers, representing 7% of

GDP. Fishers are found along the coast, harvesting conch, lobster, shrimp and finfish. Seafood is a growing part of the local diet (fish) and source of foreign exchange, e.g. shrimp (Myvett and Quintana 2002), trends found in capture fisheries and aquaculture similar to other places in the world (Ahmed and Lorica 2002). Investments in farmed fish and seafood have risen in response, notably following the passage of hurricanes. For example, while lobster output was reduced in 2000-01 by damage to marine habitats caused by Hurricane Keith, export earnings from marine products (mainly lobster and shrimp) rose in 2003, and export volumes and prices have since benefited further from certification for the EU market (EIU 2006).

The sector is ranked third in economic importance. Fishing activities traditionally revolve around lobster and conch fisheries. Shrimp, tilapia and finfish have over the last few years gained recognition as being of vital importance to national nutrition, i.e. food utilisation, and can replace chicken in the national dish along with rice and beans. Recent estimates show domestic fish consumption levels are as high as three times the volume of exports. Also harvested on a small-scale are stone crabs, marine aquarium fish, seaweed, shark, and more recently some species of squid from the shrimp trawlers. Value of exports of fisheries products are now equivalent and higher than sugar and citrus concentrate export values (Table 6.3) and are expected to continue rising due to the exponential growth, in particular, of the aquaculture sub-sector, e.g. shrimp, lobster, conch and tilapia. There are an increasing number of farms under current production, many in the form of fishing cooperatives, several of which dominate the export industry.

Potential damages to the finfish industry would be detrimental to the country's food security, in terms of supply (1st food security pillar), trade and subsistence fishers' incomes (2nd food security pillar), consumption (3rd food security pillar) and ecological externalities as threats to FPS stability (4th food security pillar). Threats to fishery outputs discovered during semi-structured field interviews with key informants, include the increase in capture fishing, inadequate resource management, alteration to critical habitats, impacts from hydrological changes, the arrival of new species, e.g. tilapia, mangrove degradation, and the lack of financing to conduct needed research on stock assessment and exploitation potential.

Food security of fisher community members also relies on fishing, aquaculture and marine-based tourism, not only for subsistence and primary income at their respective adaptive cycle level, but for export earnings at a higher-level adaptive cycle. Though commercial catches are accounted for, it is less the case for tourist-based and subsistence fisheries. Despite extensive legislative tools for management, the GoB has not been successful in the management of the country's marine resources nor been able to guarantee greater health of ecosystems, i.e. ecological wealth (Gillet 2003). Historically, management has largely been top-down and not sufficiently participatory. The need to rationalise government management of its fisheries and coastal resources has been met by some innovative partnerships, e.g. between fisher cooperatives and conservation NGOs. Thus the concept of 'resource governance' has emerged where government recognises that various non-user groups have legitimate rights and negotiate for their share of the

resource, c.f. discussed further in Chapter 7. The role of government is therefore limited to that of setting the rules of engagement and ensuring that rules are obeyed (Pauly 1999).

Southern Belize, e.g. Toledo District, serves as an important nursery ground for many species of commercial fish and shellfish. The removal of forest covers in the uplands, as a result of agriculture, aquaculture and village development, significantly accelerates erosion. Increased erosion would reduce soil fertility in the uplands and negatively affect mangrove, seagrass and coral reef productivity in the receiving coastal embayment. Alternatively, the conservation of an exiting protected corridor, linking the Maya Mountains to the Caribbean Sea is likely to enhance regional sustainable economic development (Heyman and Kjerfve 1999) and enhance FPS resilience.

These effects on coastal habitats will in turn impact the fisheries sector critical to the long-term wealth development of the country's food provision system. Estimates are that 90% of marine fish in commercial and subsistence fisheries depend on coastal habitats for all the stages in the life cycle. In this regards, they are the primary nursery areas that provide food and shelter for numerous fish species as well as general to ecosystem integrity and water quality. For example, McField et al. (1996) described the littoral forest as one of the most endangered of coastal terrestrial habitats in Belize. The forests are largely on the higher ground along the coast and cayes and subsequently are much in demand by coastal developers. The forests are important areas for shoreline protection, prevention of coastal erosion and biodiversity protection.

In response, Belize has consolidated initiatives to protect the coastal zone within a Coastal Zone Management Authority, establishing adequate environmental legislation though enforcement and monitoring have remained limited, as reported in key informant interviews. Similarly, Belize is also part of the Mesoamerican Barrier Reef Systems Project which promotes the protection of the reefs ecosystems by helping member countries to consolidate and coordinate policies, regulations and institutional arrangements for the conservation and sustainable use of these public resources including sustainable development policies for fisheries resources, tourism and trans-boundary marine protected areas, thus building FPS resilience SSC.

6.3.3 Forestry

Despite the forestry sector's vulnerability to natural hazards, e.g. due to the recent devastation in 2001 of the Mountain Pine Ridge Reserve by both an infestation of the southern pine beetle and a series of major fires, causing great loss in biodiversity (Aguilar-Støen and Dhillion 2002, FAO 2003c), strong declines in forested areas have been occurring since 1990. However, substantial tracts of tropical and subtropical rainforest still remain, estimated at three-quarters of the total land area. According to the Belize Forestry Department, only 15% of available land (under Grades 4 and 5) is suitable for commercial timber production. Difficulties have persisted in the forestry industry, partly reflecting the failure of efforts to develop a strong export market for secondary woods, e.g. sawn-wood exports accounted for less than 4% of domestic export earnings (Table 6.3).

A number of designated nature reserves, including forest, wildlife and private reserves have been created that include some traditional homelands of Maya communities, though there is concern about threats to these communities and the forest environment from further encroachment by logging and mining interests. A 20-year logging licence granted in 1993 to a Malaysian company, Atlantic Industries, caused dismay among local communities and environmental groups and was revoked in 1999, after an official report noted that logging operations had harmed local communities in southern Belize.

6.3.4 Implications for Food Security Analysis in Belize

Impoverishment is among the stoutest causal factors sustaining food insecurity in Belize. Additional factors pressuring food security and FPS resilience include the fall in world sugar prices, ecological wealth degradation, and the effects from hurricanes and subsequent flooding. Past hurricanes, for instance, have destroyed many of the banana plantations in Belize. Regarding ecological wealth, current FAO statistics (FAOSTAT 2006) show human-induced severe soil degradation, i.e. the temporary or permanent reduction in the productive capacity of land as a result of human action, levels of 29% due to land-use changes, affecting more than 16% of Belizeans, mostly in Toledo District in the south where the nation's food insecure mainly reside. In response to poverty and vulnerabilities to food insecurity, there has been an increase in shrimp farming and other aquaculture activities in Belize, which have provided more diversification, increased employment, and greater wealth, shifting and stretching the adaptive cycle of the FPS participants upwards (increased wealth), and more broadly (increased connectivity). Other areas in Belize have benefited either from the establishment of a commercial free

zone, or from construction and eco-tourism industries, and from access to micro-credit through the Small Farmers and Business Bank.

However, past micro-credit initiatives have not sufficiently targeted the indigent and vulnerable in Belize. Findings from poverty focus group sessions held among Mayas in Toledo District by PAHO (2004) show limited access to credit, linked to landlessness, and little to no economic or ecological wealth, which if owned could have been used as social wealth, e.g. collateral and insurance. These groups claim that there is neither market for some of the crops they produce, i.e. domestic produce is less favourable and valued than imported foods, and that they make limited profit from the sale of rice in particular, the national staple. It is possible to argue here that Belize's export-oriented economy has led to an illusion of food security similar to FPS described in the adaptive cycle pathological rigidity trap in maintaining resilience artificially high by retaining economic, social and ecological wealth away from less connected lower-level alternative adaptive cycles.

In fact, fears of ensuring losses of biodiversity and indigenous customary cultivation rights of the Yucatec Maya raise important issues concerning land and development policies in indigenous communities living at the margins of protected forest reserves. Unfortunately, the Belizean leasehold tenure system, implemented in the 1960s to support the Mayan control over ancestral lands has become a negative social influence leading to land under-utilisation, supporting rapid forest conversion to pasture land and increasing village differentiation in household access to traditional natural resources

(Clark 2000), affecting ecological wealth. Land tenure reforms are needed if natural resources (ecological wealth) and Mayan culture (social wealth) are to be protected.

6.4 Food Security in Belize

6.4.1 Malnutrition in Belize

The national FPS, a broad set of high-level adaptive cycles, provides for a variety of foods for local consumption, processing and trade. The main staple dish in Belize is rice and beans (with coconut milk) or rice and stewed beans, though Belizeans do not consume a variety of foods and express low dietary diversity (Jenkins 1981, Legowski et al. 1998). This is considered a cultural norm under food utilisation (3rd pillar of food security). Chicken most often accompanies the dish with finfish being consumed more often in some areas nearer the coast, though shrimp is too expensive and most often destined for export (Myvett and Quintana 2002). Diets similar to their countries of origin, such as maize-based diets, tortillas and black beans are regularly consumed by people of Mayan culture, Hispanic workers and immigrants. Regarding diets, field research for this thesis uncovered two hindrances to the traditionally-led domestic FPS: consumers had increasing preferences for foreign products (notably American through cultural and family ties, and influence from travel and satellite television for example), and the perception that domestic products were of lower quality.

The FPS resilience variable on food utilisation made the case in Chapter 3 that food security studies on intra-household inequality in food distribution and consumption typically focus on Gini ratios, on an individual's food utilisation or total dietary energy

intake, and on their nutritional status, e.g. measured by stunting and wasting. Low height-for-age anthropometric measures, or stunting, quantify the cumulative deficient growth associated with long-term food security factors, including chronic insufficient dietary intake. Low weight-for-height, or wasting, indicates a recent episode of insufficient weight gain, or of weight loss, often associated with acute inadequate dietary intake or illness. Results from the 2002 Poverty Assessment (CSO 2004) found that nationally, 7% of children had some level of malnutrition based on wasting, while stunting was found in 18% of children, mostly in southern Belize. This is slightly lower than 1979 figures showing evidence of stunting at 25% of preschool children under five years of age (Jenkins 1981). At the other side of the malnutrition spectrum, obesity figures are around 11%, almost entirely in Belize City (PAHO 2004). The country thus suffers from the burden of double-malnutrition as seen in other developing countries (Gillespie and Haddad 2003, Haddad 2003, Popkin 2003).

In addition to potential inequality in intra-household allocation of food, Gini index results, which measure inequality in economic terms, with 1 meaning all the wealth is controlled by one person, show 0.6 for Belize District, 0.4 nationally and 0.2 in Toledo District (CSO 2004). Gender differences also show higher inequalities in urban areas and lower levels in rural areas. Although there was no difference in the level of poverty nationally between men and women, there was a difference between male and female-headed households. A higher percentage of male-headed (25.5%) were poor when compared to female-headed households (21.8%). Regarding the latter, poverty was lower among single-female-headed households as compared to female-headed households with

a spouse/partner living. Similar indigent level differences were found between sexes. Results show male-headed households had higher indigent levels than female-headed households, 8.1% and 5.6% respectively. This is consistent with results from neighbouring Guatemala where men have a lesser propensity to spend marginal income gains on food for the family (Katz 2000).

In terms of micronutrient malnutrition and other health figures, over half of pregnant women suffer from anaemia, i.e. deficiencies in iron. There are no recent figures nationally on either protein deficiencies though iodine deficiencies are rare to none. Results from 1989 showed 90% adequacy levels in vitamin A. The prevalence of AIDS/HIV is considered high as an estimated 2.4% of people aged 15-49 years are affected. Efforts by the Ministry of Health to control diarrhoea, respiratory and communicable diseases have had a considerable impact in reducing infant mortality and under-five mortality rates, which are respectively 32 per 1000 live births for the period 1995-2000 and 39 per 1000 live births in 2001 (UNICEF 2004) while life expectancy has improved and remains around 72 years.

6.4.2 Alternative Estimates of Food Security in Belize

In Belize's national Food and Nutrition Security Policy (GoB 2001), food security is defined as the state in which all persons enjoy access in terms of quantity and quality to the food that they need for adequate consumption and biological utilisation thus guaranteeing a healthy and socially productive life. The focus here is on food access, the second pillar of food security, as adequate consumption, the third pillar, is believed to

follow. It does not mention availability, the first pillar of food security, nor does it refer to the fourth pillar on stability. It does refer to food security as an outcome variable and not a process variable as is resilience. According to this national policy, 33-54% of the population are at risk for food insecurity due to a lack of purchasing power, i.e. relevant to food access.

The indigent line is defined in the Belizean government's latest poverty assessment (CSO 2004), as the minimum cost of food requirement necessary for healthy existence of an individual, here again with an emphasis on food access. The cost of the food basket was used as the indigent line in each of the six districts through methods developed by the Caribbean Food and Nutrition Institute (CFNI) which generates a basket of food items that yields 2 400 kilocalories per person per day at the cheapest cost. The food items in the basket are selected from a list of basic food items that reflect the cultural dietary differences in Belize. The minimum cost daily food basket in Belizean dollars for each district is presented in Table 6.4 along with daily and monthly estimates of indigent and poverty lines for individuals. Based upon these figures from the 2002 LSMS, the percentages of indigent and poor populations are given in Table 6.5. In 2002, 33.2% of the population was considered poor and 10.8% as extremely poor or indigent⁵.

⁵ Also called the food poor, income poor, or extreme poor. It is based upon a food basket providing a minimum level of dietary kilocalories; the cost of the food basket, or food poverty line; estimates of per capita income, and distribution of the target population. Persons with income below the food poverty line are called the indigent, a sub-set of overall poverty (See Table 2.4 for a larger definition).

District	Minimum Cost Daily Requirement \$	Daily Indigent Line \$	Monthly Indigent Line \$	Monthly Poverty Line \$
Corozal	3.41	3.41	102.30	192.32
Orange Walk	3.33	3.33	99.90	178.82
Belize	3.64	3.64	109.20	222.77
Cayo	3.03	3.03	90.90	150.89
Stann Creek	3.41	3.41	102.30	179.03
Toledo	4.29	4.29	128.70	236.81

Table 6.4 – Indigent and Poverty lines by District (in \$BZ). Based on the cost of the food basket, the minimum cost daily requirement (MCDR) reflects the ‘Indigent Line’, i.e. or the food poverty line. The ‘Poverty Line’ includes the MCDR plus non-food items.

Source: 2002 Living Standards Measurement Survey (LSMS).

	Corozal	Orange Walk	Belize	Cayo	Stann Creek	Toledo	Urban	Rural	Total
Indigent Population	6.2	7.1	4.9	4.8	5.6	56.1	4.8	17.4	10.8
Poor Population	26.1	34.9	24.8	27.4	34.8	79.0	23.7	44.2	33.5
Poor Males									33.9
Poor Females									33.2
Poor Children	29.9	40.7	28.0	32.0	38.4	84.5	26.6	51.0	39.0
Poor Youth	25.7	38.2	23.4	29.1	36.3	79.3	25.5	44.2	33.9
Poor Elderly	23.4	23.1	19.8	24.6	40.1	64.8	19.9	33.5	26.5
Working Poor									29.8
Indigent Households	5.0	4.3	3.7	3.1	4.9	45.0	3.3	12.7	7.5
Poor Households	19.9	23.2	18.4	20.5	25.9	67.3	17.2	33.7	24.5
Female-heads									21.8
Male-heads									25.5

Table 6.5 –Percentage of Indigent and Poor Populations by District, Urban/Rural and Nationally from the 2002 Living Standards Measurement Survey of Belize.

Conversely, according to FAO (2003b) statistics based on national food availability, only 4% of the population are food insecure; meaning there is enough food in the national FPS on average to feed most Belizeans, as energy (kcal or KJ) availability is higher than the minimum daily requirement, e.g. 2860 kcal/person/day > 2400 kcal/person/day, pointing towards issues of food access aspects of food security and thus wealth and connectivity aspects of FPS resilience. However, the 2002 Poverty Assessment estimates indicate that 10.8% of the population were food poor or indigent, more than two and a half times the number of food insecure reported by FAO, i.e. 4%, but only a third of the lowest food insecure estimates due to the lack of purchasing power reported in the national food and nutrition security policy, i.e. 33-54%. When estimating food security, assessments often routinely capture only one aspect or pillar, focusing most often on either access or food availability. The three recent assessments of food security in Belize are summarised in Table 6.6. The table below illustrates the differences amongst how food security is measured and how this in turn portrays the differences in the severity of food insecurity in the country.

Table 6.6 - Alternative Food Security Estimates for Belize.

% of Belizean population food insecure	Lead agency, source	Dimension of food security (pillar)	Main component
33-54	GoB Food and Nutrition Security Policy (2001)	Access (2 nd)	Economic, purchasing power
4	FAO (2003b)	Availability (1 st)	Production, food deprivation
10.8	GoB 2002 Poverty Assessment (2004)	Access (2 nd) and utilisation (3 rd)	Indigent based on food poverty line

A significant distinction across food security scales, it is important to point out that country-wide statistics hide geographical and ethnic imbalances in the distribution of the food insecure and indigent. For example, Toledo District, characterised by strong Mayan populations, boasts the most food insecure in relative terms with the highest percentage of indigent population at 56.1% (Table 6.5). Estimates for indigent populations in urban and rural areas nationally are 4.8% and 17.4%, respectively, or 3.3% or 12.7% at the household level, respectively, showing greater food insecurity in rural areas. Additional results from the 2002 LSMS study shows that by ethnicity, the proportion of indigent populations are: 2.2% for the Garifuna, 5.1% for Creole, 6.2% for Mestizo, while the Maya, mostly small farmers/fishers, suffer by far the most from severe food insecurity levels with food indigent estimates at over 54.8%. Sub-nationally, all districts reported higher individual levels than the FAO measure of 4%. Only Belize and Cayo Districts, and urban areas reported lower household indigent levels than the FAO figure. Generally, households are less food insecure than individuals, an indication of poor consumption resilience, intra-household food allocation and or inequality across households.

6.4.3 FAO Methodology and Food Deprivation

The Food and Agriculture Organisation of the United Nations (FAO) uses an approach that takes into account different scenarios for population growth and technology. Its underlying analytical framework rests on a biophysical determination of vulnerability to food shortages (Hekstra and Liverman 1986). This approach, however, uses carrying capacities and treats humans as organisms whereas it has given little attention in the past to the social organisation or consumption levels of groups and individuals among the

population, a weakness now recognised (Liverman 2001) and taken into account in the FPS resilience framework, in particular through the economic, social and consumption resilience dimensions. The FAO approach implies that physical indicators will provide adequate insight into the population at risk, which is captured in the FPS resilience framework through its ecological dimension. The FAO approach also governs the selection of responses. Theoretically, if biophysical conditions define vulnerability, such as SSC define the space of resilience of the FPS framework, then modifying these conditions or moving people away from these biophysically marginal areas can reduce vulnerability, e.g. shifting the adaptive cycle above food poverty and vulnerability thresholds.

FAO's estimates are essentially a measurement of food deprivation based on calculation of three key parameters for each country: (1) the average amount of food available per person, (2) the level of inequality in access to that food, and (3) the minimum energy required for an average person (Naiken 2002, FAO 2004). Average food availability comes from national food balance sheets (NFBS) compiled by FAO every year by tallying how much of each food commodity the country produces, imports and withdraws from stocks, subtracting the amounts that were exported, wasted, fed to livestock or used for other non-food purposes, and dividing the caloric equivalent of all the food available for human consumption by the total population to come up with an average daily food intake or dietary energy supply (DES), e.g. estimates of food availability are 2 860 kilocalories/person/day for Belize (FAO 2003b). Data from household surveys are then used to derive a coefficient of variation to account for the degree of inequality in access

to food. Similarly, the minimum requirement per person, i.e. adult equivalents, for each country takes into account its mix of age, sex and body sizes, and is generally found to be around 2 200 kcal/person/day, slightly lower than the 2 400 kcal/person/day used by the CFNI. FAO reports the proportion of the population whose daily food consumption then falls below that minimum daily requirement as undernourished. According to these FAO estimates (Table 6.1), the proportion of food insecurity for Belize sits at around 4% for 1999-2001 (FAO 2003b).

The predisposition in the FAO methodology towards food availability, as reflected by DES, does not adequately reflect the effect of FPS wealth impoverishment in Belize, arguably the primary causal factor of food insecurity. Although the methodology has been improved with the use of household surveys (Smith 1998), inequity in intra-household access to food and seasonal variations in availability have not been sufficiently taken into account (Svedberg 1998). Food consumption levels derived from the NFBS also have their limitations. The reliability of the underlying data and measures of inequality is uncertain though they provide the closest consistent global and regional coverage on a regular basis (David 2002 , Senauer and Sur 2001). However, there are no annual household surveys providing adequate coverage and comparability on a regular basis in Belize.

Nevertheless, FAO is monitoring any evidence of significant changes over time that would require adjustment to their current estimation procedure. They are making efforts to improve and find alternatives to its parametric approach for estimating food

deprivation (David 2002, FAO 2004, Naiken 2002). The organisation is actively working on the integration of a suite of complementary indicators reflecting not only the food situation but also other key dimensions such as income, health, environment and nutritional status. They have also undertaken case studies using qualitative measures of food insecurity as complementary approaches to enhance the assessment of the food security situation.

6.4.4 Food Security Estimation Comparison

Table 6.7 provides a comparison between the food deprivation and food poverty methodologies. In spite of its short-comings, the FAO approach presents the advantage of being comparable across countries. Regarding minimum energy requirements, most

Table 6.7 – Comparison of Two Food Insecurity Estimates in Belize.

Dimension of Insecurity	% Food Insecurity	Summary of Approach	Strengths	Limitations
Under-nourishment. (energy) Proportion of population whose daily food consumption falls below the minimum daily requirement	4% nationally	Food Deprivation (FAO) Calculation of three key parameters: average amount of food available per person, level of inequality in access to that food, and minimum number of calories required for an average person	Establishes processes; National, regional comparisons; Lower/minimal data requirements; Easy to implement; Mainly availability, with access added on to household.	Energy, partial measure of nutrition; Masks sub-national, seasonal variability; Household, intra-household allocation, not possible.
Indigent. (food basket) Minimum cost of food requirement necessary for healthy existence of an individual	10.8% nationally 4.8-56.1% range by district	Food Poverty (GoB CFNI) Cost of basic food items reflecting cultural dietary differences, unit cost obtained consumer price index, indigent if below basic food needs	Individual and household results; Sub-national comparisons; Use of food consumption surveys.	Greater data and cost requirements; Rolling updates of basket composition and price data;

FAO – Food and Agriculture Organisation of the United Nations; GoB – Government of Belize; CFNI – Caribbean Food and Nutrition Institute.

countries accept the assumption that if the DES requirement is satisfied, then the rest of the nutrient requirements are also satisfied, while a diet deficient in energy will be lacking in protein and other nutrients. Requirements are specified for Age and Sex groups comprising the national population, an average of which, e.g. using census population counts as weights, is used as a single energy consumption cut-off. Belize and CFNI constructed a food basket that satisfies a prescribed energy cut-off while the items in the basket need to further reflect the food consumption patterns obtained from a consumption survey of the reference population and recent price data.

FAO's approach abstains from using economic variables (food poverty), relying on DES instead (food deprivation). If countries use the same dietary energy intake thresholds to distinguish the undernourished (or indigent) from those that are not, then, other things being equal, the estimated proportions of undernourished should be comparable. However, FAO's continued reliance on DES derived from NFBS instead of food utilisation estimated from household sample surveys, results in a lack of coherence between the agency's estimates and those of the countries as demonstrated in this thesis and corroborated elsewhere (David 2002). Since there are no sub-national food balance sheets compilations in general, e.g. District level in Belize, the FAO methodology cannot produce estimates at these levels, is less able to engender a country's collaboration or use of the indicators, and less efficient in targeting food poverty/insecurity alleviation resources. Apart from reporting prevalence based on food deprivation (food availability), the FAO method does not address as well the key food security questions of concern for Belize.

Findings in Table 6.7 show that the GoB's 2002 Poverty Assessment addresses more adequately the FPS resilience aspect of economic wealth, and is a more complete and accurate measure of prevalence, i.e. through food access and the use food prices, and through food utilisation by way of food needs and dietary cultural differences. However, this approach is less suited to address trade issues than the FAO method via NFBS.

In sum, to capture the prevalence of food insecurity in Belize, the two current methods appraised are suitable for measuring food security depending on the definition used. However, because they have not integrated broader FPS measures, representative of all four dimensions of FPS resilience, they do not fully assist in enhancing the effectiveness of targeting the food insecure and vulnerable. Both approaches evaluate pre-defined prevalence measures of food security, however, they are less capable of monitoring change, shocks to, and marginal degradation of, food provision systems, nor vulnerability to food insecurity, nor FPS resilience sufficiently.

6.5 Chapter Inferences

In Belize, small farms, traditional farms and the Mennonite farms, e.g. in Spanish Lookout, are responsible for producing the bulk of agriculture commodities consumed in the domestic market. However, staple food production by small and traditional farms for domestic production has declined, e.g. maize and beans, or has stayed flat, i.e. rice. This decline or lack of improvement needs to be viewed against development policies that have failed to recognise the income and employment capability and labour productivity of the domestic food sector not oriented towards exports, due in part to Belize's history,

originating in the forestry sector via exports of lumber. The comparatively small and declining amount of public investment in this sector attests to the fact that the government has limited income and employment expectations from these traditionally-led domestic food production sectors. This position could be short-sighted since export-oriented agriculture is insufficiently capable of providing employment and income, and other wealth aspects of FPS resilience, to ensure sustainable food security for a considerable segment of the rural population, and in particular, the most indigent, small and traditional farms, typically the Mayans of Toledo District. These FPS participants are without connectivity, wealth nor sufficient FPS diversity, confining them to lower-level adaptive cycles in a FPS resilience framework.

Insight from Chapter 2 on adaptive cycle pathological traps shows how such traps exist when certain groups are excluded from opportunities or promoted through added wealth growth policies and investments. The fact that a lower-level or dissipative adaptive cycle exists in Belize implicitly reveals the presence of exclusionary mechanisms for achieving food security. This is largely due to the maintenance of resilience artificially high for the higher-level export-oriented adaptive cycle situated in a rigidity trap. High resilience is maintained by retaining wealth from the lower-level traditionally-led domestic agriculture FPS, characterised by small farmers/fishers and/or milpa agricultural practices, migrant labourers in export crops, and or the Mayans in Toledo District who are by far the most food insecure.

In search of raising the level of these smaller but faster adaptive cycles, some development experts have long argued that a strong traditionally-led domestic agricultural sector is just as necessary for sustained economic growth as is a strong export sector (Demas 1965, Mellor 1988). It has also been demonstrated that the combined agriculture and food-processing sectors in many developing countries have some of the largest employment multipliers (Greig 1984). These beneficial multiplier effects on FPS resilience are currently not being fully realised in Belize because of its current state of the traditionally-led domestic agricultural sector and discontinuities between the two major FPS' adaptive cycles. These discontinuities are partly historically based but are further found in policies that fail to create suitable macro-economic conditions for the development of the local food production sector which perpetuate what may be a major weakness of current approaches to development and FPS services, that economic growth is tied only to the development of the export-oriented sector (Semple and Brierly 1998).

Food deprivation and food poverty methods have provided the food security status estimates of FPS participants in Belize. Lacking are the multiple dynamic aspects that clarify the FPS causal relationships of their food insecurity which take into account the four FPS resilience dimensions, and situate their adaptive cycles at sundry scales.

Differences between adaptive cycle scales have been identified as discontinuities (Allen et al. 2005), construed as FPS thresholds in this thesis. In the two foremost Belizean food provision systems, the national and traditional FPS, there are breaks between scales and adaptive cycles, as controlling processes of the national higher-level export-oriented adaptive cycles affect and restrain the lower-level domestic traditionally-led agriculture

adaptive cycles. The clustering of these phenomena (connectivity) at scale breaks suggests variability in wealth distribution, access, use and availability, and is greatest at these food security thresholds. This supports the proposition that adaptive cycles tend to maintain resilience thresholds or the pattern of discontinuities despite changes in their underlying composition. FPS change in Belize will occur if pushed beyond these discontinuities affecting the FPS panarchical relationships between the higher-level and lower-level adaptive cycles. This represents an opportunity for the lower-level adaptive cycles to boost food security of the indigent by revolting upwards affecting the release phase of the higher-level adaptive cycles. Individual FPS elements are in continuous motion but the adaptive cycle structure remains sturdy unless the FPS system is pushed beyond its resilience thresholds, a focus of the subsequent chapter.

Chapter 7 – Assessing Food Provision System Resilience in Belize

The food security measures reviewed and appraised in Chapter 6 are outcome indicators. Conversely, FPS resilience is a dynamic systemic measure. Carpenter and others (2001) state that resilience measures differ in two important ways from indicators: they apply to the entire system and they focus on variables, such as the four FPS dimensions, which underlie the capacity of the system to provide system services in achieving sustainable food security. Setting the context, FPS resilience, as argued in Chapter 2, is not driven by the identity of any given component of a sustainable FPS but rather by the services and functions the adaptive cycle provides, the distribution of FPS components within adaptive cycles, and panarchical relationships across scales.

Food insecurity does not consist of isolated scientific or technical problems, but is rooted in FPS system failures, discontinuities between adaptive cycles, and in connectivity between ecological, economic and social wealth. Poor conceptual development of these systems has hindered our understanding of their behaviour consequently weakening the FPS's resilience ability to respond to change. In response to this research gap, this chapter's research objective (RO5) is to test the FPS resilience conceptual framework developed in this thesis, on the Belizean FPS, to ascertain current adaptive cycles and verify if any are nested into particular pathological traps.

In previous chapters, we learn that the Belizean FPS is composed mainly of two major sets of adaptive cycles: (1) a modern capital-intensive and export-oriented agricultural

sector with higher-level broader but slow-moving adaptive cycles; and (2) the domestic traditional agricultural labour-intensive sector at an undersized and quicker lower-level adaptive cycle where the indigent mostly reside. In this chapter, strengths and weaknesses of each FPS are analysed by scale and food security pillar for insights on challenges facing Belizean FPS resilience. Strengths are factors that favour wealth, connectivity and resilience while weaknesses cripple food security and FPS resilience. The chapter pursues the research on two major agents of present and future change to FPS and sustainable food security: trade and natural hazards, with a particular focus on trade preferential treatments, and hurricanes and tropical storms, respectively. The chapter ends with an application of Panarchy theory, i.e. adaptive cycle relationships, and on pathological traps.

7.1 Overview of Challenges Facing the Belizean Food Provision System

The Belizean FPS face many challenges. Table 7.1 summarises the strengths and weaknesses of both major Belizean sets of FPS adaptive cycles by resilience dimension. Findings from the table show a significant level of FPS complexity in Belize. It captures the results from field research and reflects the responses from the semi-structured surveys of key informants broken down to discern the Belizean FPS resilience appraisal by adaptive cycle. Major agents of change impact Belizean FPS. They include: (1) macro-economic conditions, i.e. globalisation, trade, and prices changes; and (2) natural hazards, i.e. hurricanes and tropical storms. To a lesser extent, additional constraints and challenges facing the Belizean FPS include agents of change such as land title holdings, access to credit, appropriate technologies for production, processing and marketing and a

Table 7.1 – Strengths and Weaknesses of the Belizean Food Provision System by Adaptive Cycle and Resilience Variable.

Food System Resilience Variables (Food Security Pillar)	Characteristics (S) = Strength, favours wealth, connectivity and resilience (W) = Weakness, cripples food security, FPS resilience	
	Adaptive Cycle	Export-Oriented Agriculture
Land Potential and Use (Food Availability)	Historical bias (W); Large vulnerability to natural hazards (W); Diversification in production (S); Weak water security (W); Limited quality grade agricultural potential (W); Current eco-tourism development (S);	Historical bias (S); Past food security focus solely on availability (W); Large vulnerability to natural hazards (W); Reduced diversification in production (W); Quality grade agricultural potential (S); Regulation present (S) but not enforced (W); Coastal zone protection (S) though forest protection lacking (W); Current eco-tourism development (W);
Productivity (Food Access)	Financial difficulties (W); Low home ownership (W); Intergenerational effect (W); Capital investment low (W); Remittances (S); Participation in higher-level FPS through wage-devalued labour (W); Investment in gender labour productivity low (W); Sugarcane (W);	Loss of preferential treatment (W) increasing underemployment (W), a drop in real value of earnings (W) and ensuing crime rates (W); Tourism (S) though emphasis on cruise-ship tourism (W); Belize not a participant in regional trade agreements (W); Bananas (W); Citrus (S); Forestry products (S), aquaculture (S); Macro-economic conditions (W); Capital investment high (S); Corruption (W);
Intra-household Allocation (Food Utilisation)	Lower Gini ratio (S); Aggregate consumption inadequate (W); Long-term malnourishment prevalent (W); Perception of local food and safety (W);	National aggregate food availability adequate (S); Little attention to gender equality (W);
Safety-Nets (Stability)	Largely informal (S) - lack of formal institutional presence (W); Disconnect with national priorities (W); local social cohesion (S); National cultural and ethnic differences (W); Indigenous knowledge (S); Migration (S); Cooperatives (S);	Misuse of formal social assistance (W); Cohesion around national priorities (S); Regional cooperation (S); NEMO (S) though only short-term focus (acute needs (S), chronic needs (W)); Little attention to domestic goods and services production flows post-hazard (W);

lack of market information and extension. Additional directly food-related agents of change affecting the Belizean FPS include high domestic transportation costs, low local storage capacity, and higher post-harvest losses (GoB 2003). Field research also revealed risks to food safety as concerns and awareness of food-borne illnesses have recently increased, further upsetting the perception of domestic food quality by Belizean FPS participants.

Lastly, food insecurity is a key factor impinging on the willingness to innovate (Potter et al. 1999), findings corroborated by field research in Belize. Several key informants highlighted the lack of local entrepreneurship and innovation either due to the dependence on remittances, or the need to minimise vulnerability to food insecurity for these FPS participants, mostly small-scale staple food production oriented adaptive cycles.

7.2 FPS Resilience in Sub-Optimal Conditions

This section builds on selected aspects of Table 7.1 to lay bare three sets of conditions, separated by scale, upon which the Belizean FPS resilience framework rests. The first two cases, applied at the macro and household scale, show how conditions sustain uncertainty and vulnerability to food insecurity. Current macro-economic conditions will be examined as a broad FPS threat to food security. Subsequently, as the indigent are situated mainly within the lower-level adaptive cycle, closer attention will be paid to two factors of particular significance to the economic dimension of FPS resilience. They are household financial difficulties and remittances. Conversely, the third case illustrates a

community-level reaction to improving their FPS resilience when faced with vulnerable conditions. The cooperative movement at the community level will be examined to illustrate the social dimension of FPS resilience while representing institutional expressions of social cohesion. Following the analysis of these three cases, the next section will provide a more in-depth analysis of two major agents of change, with a detailed focus on trade and hurricanes.

7.2.1 Macro-economic Conditions in Belize

The present macro-economic situation in the country represents another current threat to the FPS as mounting annual deficits have generated unhealthy debt servicing levels (EIU 2006). According to Belizean Central Bank data taken in October 2005, total public-sector domestic and external debt was equivalent to 99% of GDP. Debt reduction and sustainability remain major challenges. There are strong pressures from creditors to improve these challenges by introducing, for example, public spending cuts, raising taxes and correcting the fiscal deficit, likely unpopular with Belizeans. Debt accumulation and macro-economic imbalances place the exchange-rate at risk as maintaining the currency's parity with the U.S. dollar (2:1) has been a central objective of government policy, however, this will require a reversal of recent expansionary policies, e.g. towards export markets favouring higher-level export-oriented adaptive cycles. Further threats to public finances remain, due to lax management of parastatal company finances, and from possible resurging strikes. The recent misuse of social security funds is another example of on-going corruption (World Bank 2006). Such economic vulnerability diminishes potential increases in expenditure on health and agriculture.

Fiscal management and transparency is of the essence as macro-economic conditions are a major foundation for fostering FPS resilience and for consigning food security of the vulnerable and indigent, as sectoral investments, social programs, and ecological sustainability will be negatively affected. For instance, current macro-economic conditions in Belize largely contribute to the maintenance of the conservation phase of the higher-level export-oriented adaptive cycles. Such conditions favour the wealth and connectivity of higher-level export-oriented FPS, by way of shifting economic, social and ecological wealth away from less connected lower-level alternative adaptive cycles, however, artificially maintaining high resilience for the export-oriented FPS, placing these higher-level adaptive cycles in rigidity traps. Consequently, impacts on households and participants of lower-level dissipative FPS include: (1) increased health and education expenditures, often expenses they cannot meet, (2) constraints and concentration of food choices and food intake, and (3) limited access to care, and further under-reporting of illnesses. These impacts on lower-level FPS have created financial difficulties at the household level. This is the focus of the subsequent section.

7.2.2 Household Financial Difficulties

Household ecological, social and economic wealth positions within a FPS resilience framework, determine the capacity of the household to generate income, obtain food and manage FPS risks. Most often, households are less food insecure than individuals, as is the case for Belize (Table 6.5). Household resilience along an adaptive cycle is determined by wealth position and connectivity, or the timing of access and use of wealth forms. Identifying the household's wealth position, understanding the dynamics of food

availability, access, and consumption, and examining household strategies for coping and managing FPS threats, are therefore essential to understanding FPS resilience to food insecurity. For example, higher impoverishment corresponds to lower average levels of consumption as households have difficulty with food and health related expenditures. Consequently, household-level interventions must focus on facilitating wealth accumulation, promoting alternative wealth-generating activities and facilitating FPS adaptive cycle resilience management. Ultimately, the objective of resilience at this level is to combat all forms of food poverty in order to reduce household food insecurity and vulnerability, subsequently raising food security for household members.

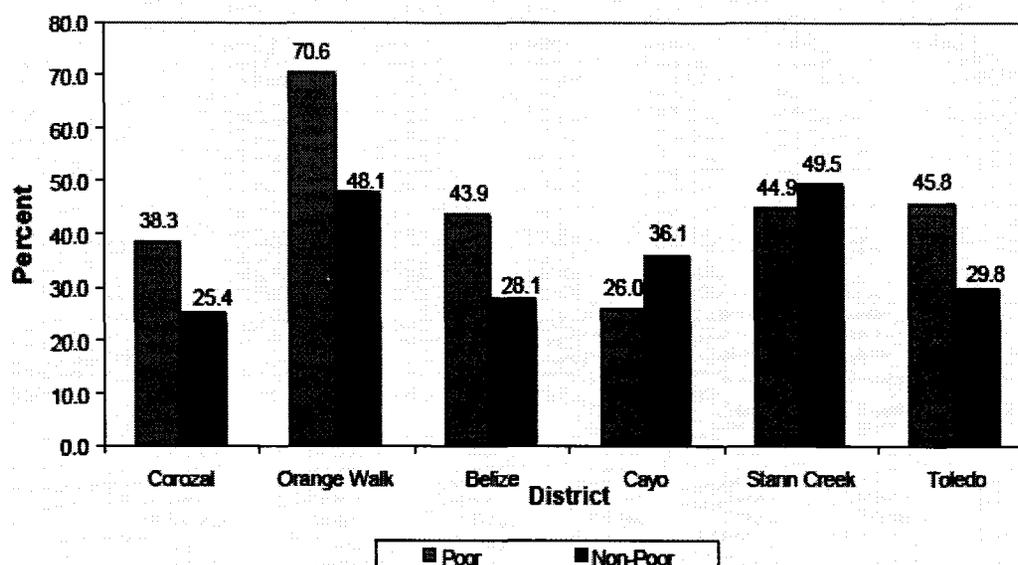


Figure 7.1 - Households with Financial Difficulties by Poverty Status and District (CSO 2004).

Average household financial difficulties by poverty status and district are given in Figure 7.1. CSO (2004) reported high economic vulnerability levels in Belize: on average,

36.8% of all households stated that they were experiencing financial difficulties at the time of the survey. The survey also found that poorer households reported higher levels of vulnerability to food insecurity. Although 67.3% of Toledo's households lived on or below the food poverty line (Table 6.5), only 45.8% of poor and 29.8% non-poor households reported having financial difficulties as demonstrated by lower Gini ratios through stronger informal social wealth measures. In fact, Toledo is the only district where the proportion of households with financial difficulties was lower than the proportion of poor households. Such findings show how a high proportion of the vulnerable non-poor in other districts across Belize are food insecure and at risk of falling below any of the three food poverty lines (c.f. Figure 2.6). They may also be pathologically trapped within the lower-level adaptive cycle. They may avoid falling below the food poverty lines by reorganising and exploiting their available and accessible forms of wealth, or their adaptive cycle may experience a dissipative shift upwards as a whole by their respective FPS participation. In Belize, such reorganisation and innovation has been achieved in part through the formation of cooperative movements, through increased wages, a shift away from major export crops to nascent production of tilapia or papaya, or through greater access to quality lands, i.e. Grades 1 and 2.

Wealth positions are also affected by inflation. In 2005, retail prices increased by 3.7%, the highest rate of inflation since 1996 as prices were mainly driven by increased taxation and higher energy costs (Central Bank of Belize 2005). The types of financial difficulties experienced by households further reveal their food insecurity and wealth position challenges. The main types of financial difficulties experienced by households were those

relating to utilities, education, health, and in fourth position, food expenses. The level of difficulty faced when paying education and health is indicative of the household's ability to invest in FPS resilience via their wealth positions. Data from the latest Poverty Assessment (CSO 2004) show how meeting health care and education costs was difficult for high proportions of all households, as 42.8% had difficulty with education, and 39.6% with health. The majority of all households facing financial difficulties reported that they had difficulty meeting utility bills (53.1%). Additional data show how transportation costs also affect wealth positions: Cayo (28%) and Orange Walk (27%) Districts had the highest proportion of households with difficulties in meeting their transportation costs, e.g. daily commutes to Belize City or Belmopan (capital), from rural areas and Guatemala. Rural households (26%) showed greater difficulty in meeting transportation costs than urban households (18%).

Basic foods are exempt from taxes in Belize though food insecurity remains a major concern as 38.4% of all households had difficulty meeting their food expenses.

Consequently, two out of five children live in poverty, meaning they cannot meet their basic food and non-food needs causing malnutrition, school absenteeism, and poor developmental growth (CSO 2004). Generally, rural households were more likely to have financial difficulty with purchasing food (44.9%), compared with any other type of financial difficulty. Conversely, urban areas are often characterised with a greater dependence on cash income as they are net-purchasers of retail food, i.e. they do not produce food and are more dependent on markets. A recent study found that 60% and 30% of consumers in Latin America and the Caribbean, respectively, purchased their

food from stores (Reardon and Berdegue 2002). In sum, rural areas in Belize generally have lower wealth positions and correspondingly lower average levels of FPS resilience as rural households are more likely to have difficulty with food, education and health related expenses. Thus, interventions to improve food security sustainably, need to become the priority as three out of every five households in Toledo District, for instance, have difficulty in meeting their food expenses, clear signs of FPS vulnerability for lower-level adaptive cycles.

Cited on occasion during field research, remittances may assist FPS participants' economic wealth positions as well as adaptive cycles within a FPS resilience framework. Remittances are thought to improve a nation's balance of payments through the influx of foreign exchange, to provide imports of capital goods needed for industrial development, to promote savings, to ensure an improved standard of living for the recipients and to encourage investment in the informal economy (Conway 1993, Russell 1986). However, remittances may be viewed negatively for development. In Stann Creek District, for example, remittances are accused of increasing economic dependency, increased social stratification in sending communities, and a failure to stimulate wealth-generating initiatives (Conway 1993, Rubenstein 1992). Such communities are structurally trapped within a FPS resilience framework as their connectivity and resilience remain low. Remittances in such cases are often thought of as simply support payments improving economic wealth but should be expanded to build additional wealth, i.e. skills and networks, to reduce dependency on wealth by raising connectivity to provoke a dissipative shift above their current resilience threshold consequently freeing these

structurally trapped communities to regain normal adaptive cycle conditions creating opportunities for raising SSC and food security levels.

Viewed over the last decade, remittances globally have been a much larger source of income for developing countries than official development assistance (Gammeltoft 2002). In Belize, recent conservative estimates show remittances of 3.5% of 1995 GDP (Central Bank of Belize 1997). Of the many uses remittances bear, they are also used to purchase consumer goods, food, clothing, school books and education, upgrading homes, and to finance the migration of other family members (Miller 1993). Wealth position analysis of Belizean FPS resilience must take into account not only economic factors, e.g. remittance flows, but also the social and cultural impacts of migration and mobility as argued in Chapter 6. Such analysis must recognise that access to, and production of economic and social wealth takes place not only abroad but also in the transnational exchanges (Georges 1990, Glick-Schiller et al. 1993, Hirabayashi 1993, Olwig 1993). Labour dynamics, i.e. mobility and productivity, as Orozco (2002) argues, need to be integrated in wealth analysis, a core component of the FPS resilience economic dimension.

7.2.3 Enhancing FPS Resilience through Community-level Cooperatives

Addressing food security issues at the community level requires understanding how community characteristics affect the food security of individual community members, as opposed to how household financial difficulties affect individual household members. For example, social institutions such as informal insurance networks, safety-ladders, and cultural arrangements, examples of social wealth, may differ by community, and the

presence or absence of such institutions affects the ability of community members to cope with FPS change. Intervention at the community level requires understanding social dimensions of FPS resilience and requires obtaining information about community wealth, connectivity and diversity. Market integration and access to public services, which is dependent on how remote a community is or its institutional ties, i.e. forms of connectivity, also influence a community members' food security status.

Responding to this institutional gap, in terms of community social wealth as engines for FPS resilience development, credit unions, and producer and service cooperatives continue to demonstrate their practicality. They have offered access to forms of wealth available to Belizeans whereby they can counteract impoverishment by identifying their common needs and by pooling their resources to meet those needs. This has resulted in increased membership and wealth positions in Belize for the last sixty years. With its unique principles of democratic ownership, collective effort and wealth accumulation, the cooperative model has offered attractive avenues for skills development, employment creation, income redistribution, rural development, import substitution and foreign exchange earnings at relatively low cost to government.

The cooperative movement has demonstrated an enduring capacity to penetrate the widest cross-section of Belizean society and ethnic communities by providing needed services, especially in coastal and surrounding communities. In addition, the cooperative movement has offered opportunities for meaningful employment and empowerment. There are 15 registered credit unions and 28 cooperatives spread throughout the six

districts of Belize. The cooperative combined membership is in excess of 69 000, nearly a quarter of the entire Belizean population and most likely over half the adult population. In addition, around 2 000 micro and small businesses are affiliated to fishing, farming and honey-producing cooperatives. Such dedication to FPS resilience at the community level and to the management of fisheries and coastal resources, Belize boasts the largest and most successful fishing cooperatives in the Caribbean. All exports from the capture fishery sector are managed through these cooperatives. This sector is a key factor in contributing to building FPS resilience through GDP growth, equitable distribution of economic opportunities and export earnings, particularly through increased savings, and a range of wealth for home construction, agriculture/fisheries production and micro/small businesses.

7.3 Two Major Present and Future Agents of Change to the Belizean FPS

7.3.1 Trade and Outlook

As described in Chapter 6, the agricultural, fishing and forestry sectors are important contributors to both the country's GDP and export earnings. For the past five decades, Belize's main source of economic growth came from the agriculture sector: from sugar, citrus, bananas, and more recently, aquaculture. This economic growth was largely a response to higher market prices being offered by preferential trade arrangements in the EU for bananas and sugar, and for citrus in U.S. and EU markets. Given that sugar and banana exports from Belize are not currently competitive in free markets (GoB 2003), the uncertainty of preferential trading arrangements due to the emergence of the World Trade Organisation (WTO), the North American Free Trade Agreement, the European Union

and proposed reforms to the Lomé Convention, has created ambiguity as to the future of the traditional markets captured by Belize after 2008-2009. Conversely, in staple commodities, the country has reached a national level of self-sufficiency and could export such goods to neighbouring countries if further investments, growth and productivity improvements are achieved. This is essential to future long-term food security for smaller producers who provide food for the domestic sector.

The EU is expected to maintain a quota system, based in part on a historic reference year for countries that have traditionally enjoyed preferential access to the EU. However, this historic preference system would damage Belize, which has to buy quotas from EU-based importers and does not control its own export and marketing arrangements. Nonetheless, a re-structuring fund has been proposed, with support for sugarcane producers, the bulk produced by small Belizean farmers. Assistance is intended to aid agricultural re-structuring where viable, and to mitigate the social and environmental impact of closures for uncompetitive producers, and to assist diversification, potentially building FPS resilience.

With the citrus crop in Florida suffering from 2005 hurricane damage and citrus canker disease, citrus prices are currently strong and likely to stay firm in the near future (EIU 2006). Conversely, the future of the EU import regime for bananas remains unclear. A recent tariff proposed by the EU on banana imports from Latin America and other non-traditional sources would allow a portion of the Belizean banana industry to survive. However, this level of protection for Caribbean producers is still being contested by Latin

American countries, which do not receive preferential access to EU markets and want all price support mechanisms removed.

Of cardinal importance to future dissipative changes to both higher and lower Belizean adaptive cycles, the sugarcane industry will suffer from a gradual cut of up to 36% on the EU price paid during the 2006-09 period. Gradually or upon termination, this will provoke losses in connectivity and wealth, shifting the adaptive cycles closer the FPS resilience thresholds away from SSC, but also within adaptive cycles along the release and reorganisation phases as FPS resilience is expressed in attempts to maintain FPS functions and ensure sustainable food security. In preparation, proposals for a new sugar factory to reduce processing costs, increase productivity and add value with the addition of an electricity generation plant running on sugarcane waste are expected to advance, as the impact on Belize will depend on the country's FPS capacity to attract investment to gain efficiency improvements. And through the current weakening of the American dollar, this will support export competitiveness and soften the impact over the coming period of EU incremental price cuts for sugar.

Current FPS resilience in Belize lies in its trading and labour practices: among exports, sugar and bananas receive trade preferences, however, the subsector must improve productivity and competitiveness to compete with Mexico in particular, as preferential treatments will be phased out this decade. Consequently, many small producers and workers from the sugar industry are shifting into aquaculture and or fishing. Bananas on the other hand are solely traded to the EU, a sub-sector which has seen some changes,

increased concentration, i.e. connectivity through larger farms; and increased productivity, though it will need to continue such investments to achieve sufficient gains to compete as its preferential access is also progressively phased out. Further trade liberalisation will encourage larger farms and make it more difficult for small farmers/fishers to continue their traditional FPS practices and livelihoods, particularly for small farmers within the sugar and citrus industries.

The susceptibility of the food export sector to external shocks is another threat to FPS resilience. This higher-level FPS only focuses on a few key commodities. Not only will the expected attrition of preferential market access to the EU impact FPS, it will be exacerbated by new regional trading arrangements for which Belize does not participate, for example, in the recent establishment of the Dominican Republic-Central American Free-Trade Agreement (DR-CAFTA), potentially eroding the country's longer-term relative competitiveness with the region. Currently, however, short-term competitiveness remains sturdy as the export sector was boosted in 2005 by strong production of citrus, papaya and marine products in addition to increased earnings (though decreasing volumes) of exports of sugar, molasses, banana, garments and sawn timber due to robust market prices. Future outlook is also vulnerable to deteriorating terms of trade, with banana and sugar prices set to fall as the phasing out of preferential trade access to the EU market continues, increasing FPS industry vulnerability. Citrus production, however, is expected to expand, benefiting from strong prices as the U.S. citrus crop suffers from hurricane damage and canker disease. In addition, the Belizean shrimp and aquaculture industry will benefit from the opening of the EU market, which has firmer prices than the

traditional American market, boosting earnings. Lastly, non-traditional agriculture and forestry sectors are benefiting from this FPS resilience diversification, gradually offsetting in part the decline in earnings from sugar and bananas.

In sum, the higher-level export-oriented FPS adaptive cycle is in a rigidity trap.

Resilience and connectivity are high, diversity is low, current economic wealth and social wealth are also high though substantially concentrated and proving redundant, supporting marginal degradation of resilience due, for instance, to low productivity reinvestment as preferential treatments erode. In fact, current erosion of preferential trade markets has already impacted the social dimension of FPS resilience regionally. Sanders (2003) found the present rate of increased crime in the Caribbean nations, parallels a downturn occasioned by their loss of preferential markets in the EU for their major commodities, in addition to a decline in tourism, an increase in underemployment and a drop in the real value of earnings. According to this author, the result is the constant erosion of the economic, social and political stability of the region.

7.3.2 Hurricanes as Threats to the Belizean FPS

Other agents of change that can affect FPS resilience in the Caribbean regionally are natural hazards. Among all natural hazards globally, floods present the greatest threat and have the greatest share at 33%, followed by hurricanes with 21% and drought at 15% (Smith 2004). Belize is highly vulnerable to natural hazards such as hurricanes as its geographical location lies right in the regional hurricane belt. In Belize, natural hazards have caused large losses in: (1) economic wealth and FPS functions and services, e.g. to

agriculture, fishing, tourism and trade; (2) social welfare, e.g. increased food poverty, unemployment, health risks, loss of human life; and (3) ecological damage and other physical, natural and environmental losses (see Andreatta (1998), along with Tables 7.2 and 7.3). Further economic wealth losses include (4) structural damage, e.g. to buildings, homes, roads and communication networks, hospitals, and schools.

Losses in ecological wealth range from harm to vegetation cover, and biodiversity to resource contamination or pollution. Additional losses have also occurred in infrastructure, and tourism and agriculture sectors. Table 7.2 shows the monetary impacts on various sectors and damage type from Hurricane Keith in 2000. Of interest, sectors with the most direct damages sustained by economic wealth and inventories were tourism, agriculture/fisheries, housing, environment and transport; while the sectors with the greatest indirect costs, sustained on goods and services production flows that ceased to be provided until rehabilitation and reconstruction, were agriculture, tourism and transport.

Hurricane events are of major concern for Belizean FPS as it is the main cause of acute losses in economic, social and ecological wealth and connectivity. Heavy rainfall is the most damaging aftermath of hurricanes, since much of the Belize's territory is made up of low-lying plains (Section 6.2).

Table 7.2 - Damage Assessment of Hurricane Keith by Sector and Damage Type
(in BZ\$'000).

Sector	Direct Damage ⁽¹⁾	Indirect Damage ⁽²⁾	Total
Economic Sector	232,222	98,358	330,580
Agriculture, Livestock & Fisheries	77,469	46,889	124,358
Industry & Commerce	30,659	15,170	45,829
Tourism	124,094	36,299	160,393
Environment	49,051	-	49,051
Infrastructure	53,042	35,837	88,879
Energy & Electricity	3,115	1,117	4,233
Telecommunications	1,536	886	2,422
Transport	46,736	33,634	80,369
Water and Sewerage	1,655	200	1,855
Social Sector	73,308	2,239	75,547
Education	2,289	749	3,038
Health	2,558	1,330	3,888
Housing	68,461	160	68,621
Miscellaneous	10,483	378	10,860
Cost of Food	1,845	-	1,845
Cost of Services	8,581	-	8,581
Cost of Services Interrupted	58	-	58
Emergency Expenditure	-	378	378
Foreign Assistance	5,176	-	5,176
Total	423,281	136,812	560,094

(1) refers to damages sustained by immovable assets and inventories (damages to property, infrastructure, buildings, installations, machinery, equipment, means of transport, damage to cropland, among others).

(2) refers to effects on goods and services production flows that cease to be produced or services that cease to be provided immediately after the disaster extending to the rehabilitation and reconstruction phase.

Source: Assessment of the Damages Caused by Hurricane Keith 2000, ECLAC

Complete damage evaluation, in monetary terms, of natural hazards in the country had not been done for any hurricane that hit the country before Hurricane Keith in 2000. An impact assessment of Hurricane Keith was done by the Economic Commission for Latin America and the Caribbean (ECLAC 2000, Table 7.3). The total damage was estimated at BZ\$560 million, of which direct damages constitute about 76% of total damages, while indirect damages estimated on the basis of goods and services production flows affected as the direct consequences of the disaster, constitute the remaining 24% of total damage costs. The total damage to the economic sector was estimated at 59% of the total estimated damage. The report further estimated that a fifth of the entire Belizean population were affected by the hurricane.

Table 7.3 - Hurricane Keith Damage Assessment to the Agricultural Sector.

Agricultural Sector	Total Area (ha)	Affected Area (ha)	Production Loss (tons)	Damages (000 Bz\$)		Total
				Direct	Indirect	
Export Crops	49,961	6,434	272,264	20,694	31,244	51,938
Citrus	25,528	2,553	81,891	8,024	5,976	14,000
Cotton	81	20	9	200	-	200
Habanero Pepper	22	19	188	331	207	538
Papaya (Papaw)	49	42	2,376	4,295	1,776	6,071
Sugar	24,281	3,800	187,800	7,844	23,285	31,129
Domestic Crops	19,930	14,300	40,559	18,934	4,821	23,755
Beans	182	87	97	157	-	157
Corn	15,827	10,994	18,485	6,928	-	6,928
Plantain	490	375	11,067	2,928	2,438	5,366
Rice	2,837	2,439	8,199	4,700	2,164	6,864
Root Crops	65	41	232	159	-	159
Soybeans	279	184	372	271	219	490
Vegetable	250	180	2,107	3,793	-	3,793
Other Fruits	1,342	294	1,451	1,523	-	1,523
Livestock (Heads/Meats)	595,258	55,699	172	14,561	4,507	19,068
Buffaloes	62	2	1	2	-	2
Cattle	52,060	288	78	181	4,507	4,688
Horses	3,000	15	-	8	-	8
Pasture	42,136	17,629	-	14,223	-	14,223
Pigs	19,000	130	35	24	-	24
Poultry	479,000	37,635	58	121	-	121
Sheep/Goats	1,000	7	0	2	-	2
Fisheries	-	-	172	9,554	6,206	15,760
Conchs	-	-	72	1,198	1,078	2,276
Fishing, Equipment, Materials & Infrastructure	-	-	-	3,357	-	3,357
Lobster	-	-	100	4,832	4,941	9,773
Other Fish Products	-	-	26	168	187	355
Beekeeping (Hives/Honey)	800	612	37	107	110	217
Capital Goods	-	-	-	12,097	-	12,097
Equipment & Material	-	-	-	260	-	260
Infrastructure ⁽¹⁾	-	-	-	11,689	-	11,689
Machinery	-	-	-	148	-	148
Grand Total	70,891	20,741	313,204	75,946	46,889	122,835

(1) mostly in farm feeder roads and some storage facilities. Lost housing in farms is also included

Source: Assessment of the Damages Caused by Hurricane Keith 2000, ECLAC

Table 7.3 details damages to the agricultural sector from Hurricane Keith. It reveals the valued importance of FPS services provided post-impact: fisheries, livestock, and export crops account for most of the indirect costs (in addition to bananas, not shown) while domestic crops and poultry, staples in Belize, accounted for much less. Only rice and plantain had some significance. A key finding from this analysis makes a case that if the release function of the adaptive cycle is to perform well and use forms of wealth under reduced connectivity, as it rebuilds food security through resilience when hazards and other acute changes occur, more attention must be given to traditionally-led domestic FPS services and functions reflecting national food security needs. For instance, Hurricane Iris (2001) had a large impact on the banana sector and reconstruction for the food poor and indigent has been difficult. According to the 4th Report on Assessment of Damages Due to Hurricane Iris (Ministry of Natural Resources 2001), nearly ten percent of the Belizean population were directly affected, the majority from Toledo and Stann Creek Districts. The report points out that damages from the storm's passage were greatest in the area of agriculture and fisheries, tourism, forest/biodiversity resources, and housing. The estimates indicate that the total cost of damage amounted to BZ\$390 million with agriculture accounting for the majority (52.6%) of this cost, while housing (22%) and tourism (20%) accounted for a sizeable proportion. CSO data also indicate that one in every three households in the Toledo District was affected. The majority of households (56.1%) affected reported that their homes were partly damaged or completely destroyed, while 40.5% reported that their crops or livestock were destroyed.

7.3.3 Lessons and Dynamics of FPS Resilience in Belize

In terms of hydrological risks, changes stemming from hurricanes and tropical storms have provoked large acute FPS changes in adaptive cycles pushing them across resilience thresholds (Section 2.3.3), inciting dissipative changes. Each hurricane has caused serious damage to FPS through crops, infrastructure, and housing and tourism facilities⁶ in recent years. Additional hydrological threats to Belizean FPS ecological wealth include severe storm events, sea-level rise, large-scale warming, increased solar irradiance, and climate change which impact coastal waters areas through higher temperatures and coral bleaching (Harborne et al. 2000). A closer focus on Belizean coastal waters shows additional problems stemming from over-fishing, sedimentation, agricultural run-off, and sewage. While storms may produce dramatic local reef damage, they appear to have little impact on the ability of coral reefs to provide food or habitat for fish and other animals (Lugo et al. 2000). Rainforests also experience enormous increases in wind energy during hurricanes with dramatic structural changes in the ecological wealth such as vegetation. The resulting changes in forest microclimate are larger than those on reefs and the loss of fruit, leaves, cover and microclimate has a great impact on animal populations. Recovery of many aspects of rainforest structure and function is rapid, though there may be long-term changes in species composition. While resilience has maintained reefs and rainforest in the past, human impacts may threaten their future ability to survive (Lugo et al. 2000).

Buffering that helps a system cope with surprise (Folke et al. 2002) can be lost, that is its resilience is the tendency of a system to remain unchanged, or nearly unchanged, when

⁶ The decision to move the capital from low-lying Belize City to Belmopan was taken after Hurricane Hattie in 1961.

exposed to perturbation (Hansson and Helgesson 2003). For example, loss of perennial vegetation as shown for Belize and consequent elevation in water tables, seasonal or acute, saturates the subsoil, reducing its ability to absorb further rainfall and its physical buffering capacity, particularly under conditions of greater than average rainfall, as is the case of Toledo District receiving four times the rainfall levels compared to northern districts. Often a system can be stabilised by increasing the size of a buffer (Meadows 1970), or SSC and bands of tolerance. When there is little or no ecological buffering capacity, or it has been exceeded, the control shifts to regional social and economic buffering capacity, respectively in terms of adaptive resilience factors (Allison and Hobbs 2004). The potential impact could be a retraction of the area under annual cropping, with areas being abandoned or a threshold being reached in the number of farmers/fishers, and rural under-development at the margins exiting the FPS.

Citrus production is concentrated in the country's south-eastern coastal plain in Stann Creek Valley. It is illustrative of low FPS diversity and high FPS connectivity.

Consequently, because of hurricane damage to citrus groves in 2001, production in 2003 of oranges and grapefruit were 28% and 26% below peak values of 2000. Past hurricanes and tropical storms have intermittently contributed to short-term reductions in agriculture production and exports, and increases in food imports, agricultural inputs and other investments in FPS wealth. The aggregate impact from Tropical Storm Roxanne (1995) and Hurricane Keith (2000) in Northern Belize together with tropical storm Chantal and Hurricane Iris (2001) in Southern Belize resulted in more than US\$200 million in losses/damages to the agriculture sector alone. They also caused short-term shortages of domestic commodities such as rice, maize and beans, and contributed to reduced exports

of shrimp, lobster, papayas and bananas in corresponding years, not to speak of damages caused to infrastructure (GoB 2003). Banana growing operations were also devastated by Hurricane Iris in October 2001, which affected almost all plants and brought exports to a complete halt until new plants reached maturity in April 2002, reaching full circle of an adaptive cycle following a release phase, reorganisation and growth phases, back to a conservation phase within new steady-state conditions (SSC) and related thresholds. Banana exports recovered in 2003, around the same point as their previous peak output in 2000.

Prospects for the export-oriented agricultural sector are mixed. Earnings from agriculture will suffer not only from hurricanes but from deteriorating terms of trade as well, with banana and sugar prices set to tumble as the phasing out of preferential trade access to the EU market moves ahead, jeopardising the survival of these industries nearing SSC thresholds approaching the release phase of their respective adaptive cycles. Citrus production is expected to expand, benefiting from firm prices and the prospect of cross-border joint ventures with Guatemala. Earnings from the shrimp and farmed fish (aquaculture) industry will benefit from the opening of the EU market, which has firmer prices than the traditional US market. Non-traditional agriculture and forestry can also benefit from the government's diversification efforts, source of innovation in an adaptive cycle's growth phase, which will partly offset the decline in earnings from sugar and bananas.

In sum, water is a crucial agent of change shaping the Belizean FPS. Most agriculture in Belize is rain-fed, a dependency limiting production where shortages may be common, affecting both commodity prices and incomes. Although dry seasons influence not just crops but livestock, dairy production, and hatchery productivity for instance, the country does have appropriate water basins and natural resources (FAO 2003c) offering strong ecological wealth for additional increases and diversification of agricultural production. Much of the alternative ecological wealth used in Belizean FPS have been converted for agricultural purposes in Belize, resulting in land use change for export-oriented commodity production, increasing specialised monoculture practices while decreasing FPS diversity and resilience. However, there are costs to maintaining such capital-intensive productivity of export-oriented FPS on ecological wealth, e.g. soil degradation, acidification and soil erosion, drainage, and revegetation, which may be mitigated through lower input prices, the adoption of new grain varieties, of new technologies and agricultural practices (Passioura 2002). Such costs exemplify how resilience of export-oriented FPS may be restricted to lock-in pathological traps.

7.4 Pathological Traps and Panarchy Theory in Belizean FPS

The numerous strengths and weaknesses of the Belizean FPS (Table 7.1) have provoked a departure from food secure steady-state conditions (SSC) and resilience bands, passing through previous thresholds to achieve two particular dissipative states, a higher- and lower-level adaptive cycle and ensuing discontinuities. The lower-level FPS adaptive cycle is not an entirely impoverished system as some FPS wealth and strengths remain. However, the higher-level adaptive cycle maintains much greater wealth in support of its

own adaptive cycle foreloop conservation phase at the expense of the lower-level FPS (hierarchical confinement). The higher-level FPS catches such wealth from lower-level FPS for its own purposes in efforts to maintain FPS resilience homeostatic mechanisms and preserve its adaptive cycle conservation phase within SSC, by (1) paying low wages for undervalued lower-level FPS labour; (2) having developed industries and planted crops upon better quality lands, e.g. Grades 1 and 2; and by capturing (3) investments favouring the export sector historically; and (4) formal safety-ladder investments following the passage of hurricanes, illustrated in the previous section.

The lower-level FPS is neither highly connected, with little command over Belizean FPS, nor rigid, or inflexible such as its higher-level food regime, the latter having squeezed out diversity by focusing on a few commodities for key markets. The lower-level FPS has a broader more diversified production base including maize, beans, rice, finfish, fruits and vegetables, honey and cocoa. Apart from sugarcane, most lower-level FPS also do not directly rely on regional or global markets, nor on broad adoption of highly mechanised or sophisticated technology. They are labour-intensive adaptive cycles, as opposed to their higher-level more capital-intensive counterparts. Hence, lower-level FPS participants lack power, i.e. FPS connectivity, and require enfranchisement if they are to take advantage of revolting back up to the higher-level food regime's adaptive cycle conservation phase. The lower FPS subsequently and jointly follow the latter's release phase at key moments, when the normally weak panarchical interactions across both levels are strengthened, once acute change from hurricanes has pressured FPS resilience to move away from SSC anew and surpass corresponding resilience bands, or once

sufficient gradual change has occurred due to erosion of current preferential trade arrangements over the 2006-2009 period, and or further erosion of macro-economic conditions.

Two major findings of this thesis for alleviating current indigent levels and ensuring future long-term food security in Belize are (1) the discovery and recognition of local Panarchy theory, i.e. the FPS revolt and remembrance panarchical relationships between the two major FPS and respective sets of adaptive cycles; and (2) the confinement of several adaptive cycles in each major FPS to pathological states, situated in lower-level structural traps (traditionally-led domestic agriculture) and higher-level rigidity traps (export-oriented agriculture). Concerning Panarchy theory, the conservation phase of the higher-level FPS is the main component for alleviating food insecurity of FPS participants in lower-level adaptive cycles. Figure 2.3 teaches us that both FPS levels experience their own adaptive cycles' dynamics within the constraints of the broader, slower higher-level FPS's conservation phase. When the faster and lower-level dissipative FPS adaptive cycle enters its release phase and experiences a collapse, it must overwhelm the higher-level and slower adaptive cycle by either triggering a crisis in that level's conservation phase, or taking advantage of changes proper to the higher-level food regime once both adaptive cycles experience collapse following the three main triggers affecting the Belizean FPS suggested in this research, i.e. (1) hurricanes, and the erosion of both (2) preferential trade arrangements, and (3) macro-economic conditions. The second cross-scale panarchical interaction important at times of change and renewal, is remembrance, or opportunities and constraints for reorganisation (backloop) of the lower-

level adaptive cycle, strongly conditioned by the conservation phase of Belize's larger and slower export-oriented FPS.

In sum, lower-level FPS adaptive cycles in Belize are characterised by: (1) a high potential for change, typified by available wealth forms which are either not accessible or undervalued, and often by intensive wealth activity highly vulnerable to change; (2) low connectivity, highly affected by outwards relations with higher-level FPS adaptive cycles, and little enfranchisement; and (3) low resilience, supporting repeat losses of FPS functions following change, i.e. as domestic crops receive little post-hurricane reinvestments demonstrated by Section 7.3.2, and little if any absorption capacity to externalities from hurricanes. Low-level FPS and adaptive cycles are thus caught in a backloop of recurrent release and reorganisation, having deviated from acceptable SSC and FPS flows. They are unable to develop adequate FPS relationships due to remembrance, conditioned by the higher-level adaptive cycle's conservation phase, as the chronic food insecure, indigent and malnourished are frequently found here with labour and knowledge as their forms of wealth, undervalued by the higher-level FPS, unable to rebuild wealth through time and across generations. Current household financial difficulties and levels of malnourishment further perpetuate low-labour productivity maintaining lower-level adaptive cycles in pathological structural traps. Conversely, Belize's concentrated highly connected economy has focused post-war (WWII) higher-level adaptive cycles on a few key export commodities, notably, citrus, bananas and sugar, reducing FPS diversity. A second pathological state, the rigidity trap, thus applies to the Belizean FPS. With increased connectivity, capital-intensive wealth, and capacity

to maintain FPS functions towards export services, these adaptive cycles restrict both (1) economic, social and ecological wealth, and (2) connectivity, away from lower-level alternative adaptive cycles, i.e. FPS focused on traditionally-led domestic agriculture and who do not take part in foreign trade.

7.5 Chapter Inferences

This chapter has advanced the conceptual development of FPS resilience and ability to respond to change, with applied examples from Belize. Key FPS resilience characteristics which describe the system dynamically are the four adaptive cycle phases, SSC and corresponding thresholds, and the three framework parameters: wealth, connectivity and diversity. With regards to the layered forms of wealth (Figure 1.1), economic wealth and ecological wealth are at opposite tiers, with social wealth in between. Within a FPS resilience framework, ecological wealth is broader, slower while economic wealth changes rapidly. Ecological wealth spreads resilience while economic wealth increases connectivity, offering additional absorption capacity until excessive concentration reduces wealth, limits response, i.e. homeostatic mechanisms, locking-in fixed resilience due to redundant capacity. Ecological wealth is more sustainable and closest to ensuring long-term food security while economic wealth is less sustainable, always changing, hardest to build, and toughest food security pillar to achieve. From a spectrum of ecological towards social and economic wealth, more aggregated forms of wealth are less FPS-oriented while providing relative diminishing FPS functions and services.

Information gained from changes to FPS resilience economic, social and ecological dimensions in Belize can be used not only to determine which households, communities and sub-national regions are vulnerable to consumption shortfalls and malnutrition, but how vulnerable they are, according to chosen food poverty thresholds, and how close they are to a crisis. This requires precise knowledge of the agro-ecological, socio-economic and institutional conditions prevailing in those areas. As a result, the constraints, incentives and solutions are site, and time-specific. The state and nature of multiple stressors depend on how many FPS participants in a given area also perceive the risks or benefits of investing in coping mechanisms, with reference to food expenditures, c.f. household financial difficulties. That in turn depends on prevailing economic, social and ecological incentives that affect potential returns; it also depends on trends in production and the overall availability, affordability and quality of food for those who need it most, i.e. the indigent. Current macro-economic conditions in Belize presently and can further hinder these incentives.

Numerous adaptive cycles of both major Belizean FPS are pathologically trapped: the higher-level FPS is rigid while the lower-level cycle is structurally cornered. The prevalence of several FPS weaknesses under Tables 7.1 is progressively increasing, preparing both adaptive cycles for a systemic change episode particularly following the elimination of trade preferential treatments, or future hurricanes. If current system-wide SSC do not improve, through sufficient and sustainable wealth accumulation, increased FPS connectivity and diversity, further food security degradation will occur. Success has been possible, demonstrated by cooperatives in Belize, when societies have found social

cohesion and come to understand that low connectivity, food insecurity and wealth losses are preventable and manageable, and when they have mobilised to demand that their political and social institutions create conducive environments, expand the FPS's infrastructure capacity, and establish, monitor and enforce public health and natural resource policies that promote and support food and nutrition security.

A great deal of attention to food security is spent on availability of supply, access to food and consumption or food intake, most often at an end-user perspective. However, less attention if not neglect is given to the food provision system as a whole and its food security risks embedded within. It is the development of food security that is paramount. As such, the fostering of FPS resilience is a natural extension to maintaining food security. It is not a direct focus on the food insecure themselves, the consumer, farmer/fisher or FPS provider, and how to influence them, but rather the developers of food security, wealth accumulation/allocation and FPS connectivity and diversity, and how to influence them. Understanding food security drivers is essential when adjusting policies around FPS to be consistent with food security priorities agreed upon around social cohesion. Geographic, demographic, cultural, social, ecological and economic and other conditions vary widely across Belize and a large variety of consumption, coping mechanisms and food security patterns are expressed. FPS policy must be used to alter those necessary patterns in ways that reduce FPS resilience sensitive to adaptive cycle differences.

The reason why there is much food insecurity in Belize although food abundance and DES are sufficient, is mainly due to disparities in forms of wealth and connectivity due to panarchical relationships between the two major sets of adaptive cycles in Belize. Higher-level adaptive cycles have benefited from quality land, investments and low-wage labour. Consequently, lower-level adaptive cycles are generally considered vulnerable as they remain situated below the national FPS 50% probability vulnerability threshold while other cycles are situated even lower, below the food poverty threshold where Belize's indigent reside, the nation's extreme poor, without the capacity to reorganise nor exploit FPS functions. The FPS for them is untenable, maladaptive and malnourishing. However, the country has been, and remains heavily dependent on export earnings from agricultural trade for macro-economic purposes. These trade goals have overridden other development goals, notably domestic goals consistent with food security and FPS resilience. To address these inconsistencies, FPS resilience-sensitive policy is needed, e.g. a policy that minimises distortions of wealth allocation and dislocation of existing production and trade systems (Nugent 2004). Ultimately, such a policy should be measured against the multiple objectives of all sectors of society, with priority placed on providing sufficient, safe and nutritious food through a stable, sustainable and equitable FPS (adapted from Tansey and Worsley 1995). Chapter 8 pursues this analysis.

Chapter 8 – Food System Resilience-Sensitive Food Policy and Social Cohesion

Understanding FPS changes is fundamental for the proper study of food security as choice of policy response must consider the ecological, social and economic conditions under which such FPS changes occur. In essence, this thesis reflects an approach that interprets FPS resilience to change based on four resilience dimensions set out to achieve food security, i.e. the FPS' priority sustainability goal, accounting for the role of wealth, connectivity, and diversity, as well as panarchical relationships between adaptive cycles. To achieve this priority sustainability goal, social cohesion around food security must be garnered. Social cohesion is both an instrument of achieving widely shared FPS ideologies and values. It is also an analytical tool used to highlight the uneven distribution of wealth and opportunities, and increasingly related social struggles (Duhaime et al. 2004). The application of social cohesion is motivated not only by its conceptual considerations but by food insecurity concerns highlighted in Table 7.1 by both the National Food and Nutrition Security Commission and the key informants and stakeholders interviewed who wish to make food insecurity a dominant agenda for all Belizean FPS participants. The desired effect of using social cohesion is to inform the implemented national Food and Nutrition Security Policy (FNSP) to reduce FPS resilience disparities and achieve long-term food security. With social cohesion, governments may take concrete actions. For food policy to properly meet this significant challenge, it must reach, and demand responses, across policy sectors (Barling et al. 2002). More specifically, FPS resilience-sensitive food security policy can contribute to meeting this challenge.

The following section will address the salience of social cohesion raised in the last chapter. Concepts of policy, and resilience relevant to food policy, will then be introduced and synthesised in subsequent sections. This chapter will then review and assess Belize's FNSP for aspects that affect FPS resilience. The chapter focuses on policy-building. It will not tackle a range of sectoral policies, e.g. agricultural, environmental, or economic, but rather concentrate on the FPS resilience-sensitivity of the existing FNSP.

8.1 Social Cohesion as a Means of Ensuring Food Security

Using ecological wealth as an example, the basic structure of a societal model as described by Kasperson et al. (2001), shows that failures to address ecological loss can occur at various points in the system and eventually feed back into the system's driving forces. Conversely, these driving forces recurrently feed into proximate causes of environmental change (Stern et al. 1992). Such changes are not only linked to driving forces but also to the vulnerability of ecological wealth and its corresponding resilience dimension within FPS. The level of absorption of these changes varies among the degree of resilience. Resulting system degradation is a potential signal to society, an opportunity for it to respond and learn accordingly, i.e. for adaptive cycle self-organisation. Then social amplification or attenuation occurs where the FPS participants assess the severity of change through information flows as threat-related responses are undertaken following the release phase of an adaptive cycle. Then in the reorganisation phase, once social construction of a food problem has transpired and society has been mobilised, a formal or

hidden response is developed by building broad participation into decisions, or enfranchisement, about the definition of the food problem (Fischer 1993). Such broad participation channels social cohesion.

Previous chapters have revealed two major FPS in Belize, each with respective social norms which contribute to the development of adaptive cycle pathological traps. The fact that a lower-level SSC or dissipative adaptive cycle exists in Belize implicitly reveals the presence of remembrance and exclusionary mechanisms within the national FPS, e.g. panarchical segregation and hierarchical confinement. Prior research in this thesis showed that if lower-level FPS are to revolt back towards higher-level SSC to build and shield wealth and increase connectivity, it will require further investments, improved rural infrastructure, technologies and labour productivity, with particular attention given to women, and access to higher-potential markets, as current resilience is based upon limited wealth, market participation, technology adoption, investment decisions and coping mechanisms. The previous chapter ascertained that once social cohesion is achieved, social relations are strengthened through FPS safety ladders, i.e. sequential mechanisms of FPS resilience-sensitive food security interventions supported through social consensus. Those mechanisms put in place reduce negative consequences of panarchical segregation including disparities, inequalities, discrimination, undervalued wealth and social exclusion, all characteristic of the panarchical relationships between the two major FPS sets of adaptive cycles in Belize. Equality in wealth opportunities for both lower-level dissipative FPS as well as higher-level FPS is a necessary condition for social cohesion. Overall, social cohesion is a comprehensive concept including political, social,

economic *and ecological* integration (Qadeer and Kumar 2006, italics added). It is the degree of panarchical segregation and adaptive cycle discontinuities that are indicative of social cohesion having been achieved. Thus, raising lower-level FPS wealth and connectivity contributes imperceptibly to shared food security values and goals of tenable Belizean FPS.

The higher-level FPS adaptive cycle in Belize demonstrates high connectivity as participants have common values and FPS services, and as the country's past has facilitated the socialisation of the FPS in an export-oriented culture. It also demonstrates strength in (1) economic wealth, e.g. investments and infrastructure; (2) social wealth, e.g. political stature; and (3) ecological wealth, e.g. quality lands. These assets have driven the national economy and given the adaptive cycle access to institutional services, e.g. financing. Over time, such increased wealth and connectivity along with limited diversity, institutional inflexibility, have nested the adaptive cycles in rigidity traps.

Such inflexibility has limited the range of FPS services and facilities necessary for food security, which distinguishes the lower-level FPS apart from the higher-level cycles. For this lower-level dissipative FPS to break out of its structural trap into acceptable and normal FPS flows and services, FPS participants require movement out of food insecurity and onto a trajectory of wealth accumulation and greater connectivity. However, the varying nature of resilience among FPS participants affects their ability to climb out of food insecurity, and vulnerability to food insecurity, through their respective adaptive cycles. Ascending adaptive cycles require gradual steps while FPS resilience capacity

develops. Such processes that promote social cohesion must be laddered. Kabeer (2002, adapted) depicts such ladders by food poverty threshold (c.f. Section 2.4.2):

- Those who are physically unable to take advantage of economic opportunities because of age, disability and ill-health are also least likely to be able to take advantage of certain forms of safety net measures, such as public works programmes, or to be able to contribute to social insurance schemes. Some form of non-contributory social assistance may be the most appropriate response for instance;
- Those who may be physically able but lack economic wealth, and they are the vulnerable non-poor, and households above the food poverty line but precariously so;
- For moderately poor households and the vulnerable non-poor who are most likely to benefit from some combination of protection and promotion, which gives them a more secure base from which to diversify into higher return, but higher risk activities;
- For the extreme poor, or indigent, who face highly irregular and uncertain flows of income, the priority may be to reduce fluctuations and build up wealth; and
- For those who face social discrimination as well as economic deprivation, issues of voice and agency may be as important as social protection for such groups.

Food policy measures for vulnerable and indigent groups must take account of the different capabilities as well as different needs of these FPS participants groups. As

Kabeer (2002, adapted) suggests, measures can start with the FPS wealth and activities that households currently manage by gradually building up their capacity to manage a wider range of FPS wealth and higher value activities. For instance, Figure 8.1 shows the progression of FPS safety ladders as food security increases over time (Bokeloh 2005).

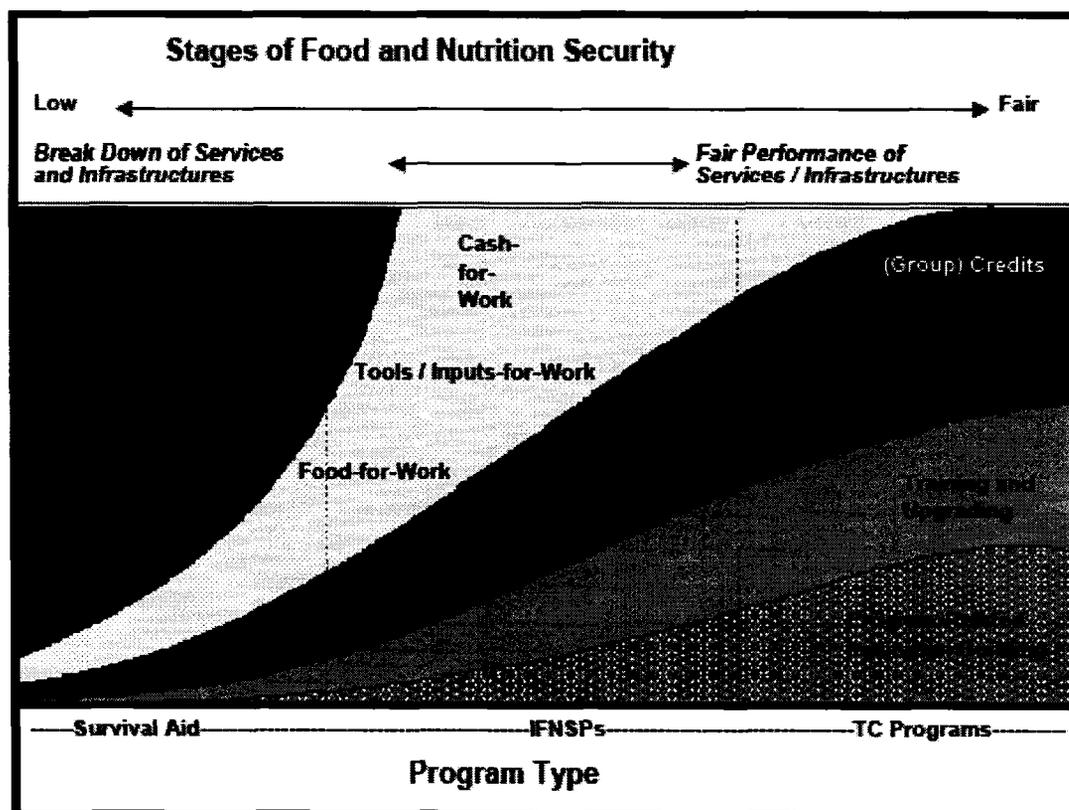


Figure 8.1 - Sequential implementation tools of FPS resilience-sensitive food security interventions supported through social consensus in different stages of food insecurity (Bokeloh 2005).

As food security improves, the release phase of an adaptive cycle leaves behind FPS function breakdowns, e.g. emergency conditions, to shift towards reorganisation and growth phases in more food secure conditions. The left side of Figure 8.1 shows very

high food insecurity. In these circumstances, relief programmes provide survival aid and assure wide distribution of basic commodities such as food or medicine. These programmes must react rapidly and flexibly to secure the survival of FPS participants. In fact, Belize is a regional leader in areas vulnerable to external stressors such as in natural disaster preparedness and relief coordination efforts due to a decision taken by the GoB in relation to disaster management with the enactment of specific legislation and the establishment of the National Emergency Management Organisation (NEMO). The organisation focuses on education of emergency preparedness and short-term responses to hurricanes in particular. It does not, however, have the scope to cover more long-term impacts from changes on FPS.

Once survival of the indigent and vulnerable is ensured, measures can be implemented to build a basis for sustainable development that relies on the self-organisation of renewed adaptive cycles and capacity of FPS participants. In this reorganisation phase, Integrated Food and Nutrition Security Programmes are required (Figure 8.1 middle column). Self-help measures such as cash-for-work, food-for-work, tools or inputs-for-work can be used to construct basic economic wealth, e.g. infrastructure such as drinking water supply, sanitation, irrigation channels, reforestation, and health posts. At this point, adaptive cycles may have adequate DES but the quality of food may still be insufficient. As a result, specific micronutrient interventions may be required. The right side of Figure 8.1 reflects adaptive cycles that are above food poverty thresholds, and wealth and connectivity positions that allow for the implementation of technical cooperation, e.g. the

implementation of credit and saving programmes, capacity building and institution building, and the start of adaptive cycle growth phases.

Following short-term reorganisation, adaptive cycle growth phases focus on longer-term, more robust FPS resilience, wealth and connectivity. This phase also follows a ladder or incremental approach, i.e. assistance ranked by FPS resilience, as capacity develops. Kabeer (2002) cites two examples of FPS resilience ladders in rural areas, characteristic of lower-level adaptive cycles, more specifically, a livestock ladder followed by a capacity building ladder. This pattern has been adapted and further developed for FPS resilience purposes below. The two ladders initiate the adaptive cycle foreloop sequence as the narrative below will demonstrate how wealth, connectivity and diversity lead to higher SSC and FPS resilience, ensuring more sustainable food security. The first step starts with a livestock ladder contributing to the economic FPS resilience dimension with regards to productivity, where the indigent may only be able to manage poultry and pigs when they first adopt rearing as a livelihood strategy, but with increased experience and resources, may later graduate to larger livestock such as cattle. The second step, a social wealth ladder, improves training where health needs are likely to be a priority for the indigent whose physical labour forms the basis of their livelihood strategies such as in Toledo District or FPS participants in lower-level adaptive cycles. Thereafter, once health needs are assured, and some degree of temporary food security attained, other forms of wealth may begin to assume significance: basic literacy and numeracy leading onto accountancy and business skills. Similarly with such skills, demand for market outlets grows requiring further laddering of rural infrastructural development, with improved

roads come larger volumes of commercial and civil transportation due to the reduction in transport costs. Consequently, further innovation occurs, trademark of the growth phase of the adaptive cycle, phase characterised by more readily available resources and wealth, the accumulation of structure, and higher resilience. As structure, connections and FPS services and complexity among system components increase, more resources and energy are required to maintain them. This leads FPS participants, for instance, to increase productivity by switching from their own, to commercial means of transport, as the number of markets alongside the new rural infrastructure, and relative incomes increase, with greater access to improved markets as they become available. As a result, greater demand for FPS inputs and services increases with improved access to higher-level FPS services and components although demand for such FPS services may be indirect as FPS participants shift away from agriculture and other primary sectors into non-agricultural activities galvanised by the presence of the improved rural infrastructure. This can lead to a conservation phase though constraints remain. Availability of market information and market prices is nonexistent in Belize. This is a FPS weakness (Table 7.1), if corrected, could potentially achieve better prices for lower-level FPS goods and services, and greater integration of national markets across both FPS. Similarly, agricultural extension services remain weak as field research uncovered (Table 7.1). A more integrated provision of credit, marketing channels, market information and extension advice are FPS services that the government could play more effectively in contributing towards the productivity of the indigent, in particular, and all FPS participants more broadly.

Availability of credit would allow a greater number of FPS participants to increase their wealth base, smooth consumption and improve nutrition (Section 3.1.4). Elsewhere, access to credit has allowed households to diversify their livelihoods so that financial difficulties and irregular returns from trade or agricultural wage labour could be supplemented by lower paid, but more regular, forms of self-employment (Kabeer 1998, Khandker et al. 1998). In some cases, the decision to take up self-employment in place of waged employment, particularly waged employment in agriculture, represents a decision to move out of a badly paid form of labour, to a possibly better paid form of labour (Kabeer 2001). A desired shift upwards of the adaptive cycle could then occur if social cohesion around credit is successful. Lastly, building upon these arguments around credit, there is increasing evidence to suggest that the practice of targeting women in financial interventions has had the effect of modifying the basis of their resilience (Kabeer 2001, Zaman 1999). It has increased women's own sense of self-worth as well as the value accorded to them through social cohesion by other FPS participants; through a greater role in household decision-making; reduced levels of domestic violence; acquisition of assets in their own name or on a joint basis (improving intra-household allocation, and the FPS consumption resilience dimension); greater mobility in the public domain; increased awareness of their own rights; greater ability to save; and a safe place to keep their savings (Kabeer 2002, UNICEF 1998).

This section has demonstrated several cases of adaptive cycle growth following release and reorganisation phases highlighting the potential improvements to the current fragmented provision of FPS goods and services for the lower-level FPS. It highlighted

how food policy measures ought to take account of the different capabilities as well as different needs of the indigent and FPS participants. It is essential that analysis of policy impacts on factors determining food security is complemented by a differentiated view of alternative adaptive cycles, particularly the conditions and sources of FPS wealth of those FPS participants who are either indigent or vulnerable to food insecurity. To achieve food security in Belize, social cohesion must be generated with marked emphasis on equality in wealth opportunities across both FPS. In fact, it is by full participation of both adaptive cycles reaching social cohesion that increases the sustainability of food policy measures ensuring food security for all FPS participants. The subsequent sections will now focus on policy with a shift towards an increased sensitivity to resilience, while integrating non-linearities in FPS, and discerning the benefits of promoting social cohesion, self-organisation, and FPS goods and services for achieving long-term food security.

8.2 Placing Resilience in Policy

8.2.1 Food Policy

Resilience is a concept to draw attention to the need to incorporate non-linearities in models of socio-ecological systems (Lélé 1998). Levin and others (1998) have made the case for applying resilience analysis to coupled ecological and socio-economic systems, and called upon policy-makers to build resilience into such systems. In fact, when resilience is placed as a core element within a sustainable food policy framework, the ability to respond adequately to change and uncertainty becomes inherent to corresponding derived sustainability management strategies (Brinsmead and Hooker 2004). This is particularly valuable because adjusting to change and uncertainty is a core

issue for sustainability policy. However, the message of resilience is more radical for policy-makers than that of sustainability (Adger 2003b) as branches of natural and social science that most directly inform public policy appear to be less aware, if not unaware, of such phenomena, often restricting themselves to linear systems theory, as Lélé (1998) argues, attesting to their hegemony over the policy-making process (Holling et al. 1995, Norgaard 1987). In fact, evaluations of food security monitoring systems in many countries have found the links between analysts and decision-makers weak. Stronger dialogue and cooperation would increase the timeliness, flexibility, and effectiveness of monitoring and intervention systems (Kennedy and Payongayong 1992, Tucker et al. 1989).

Promoting FPS resilience means changing the nature of decision-making to recognise the benefits of self-organisation and governance in promoting social cohesion around food security. Promoting resilience is concerned with the knowledge required to facilitate robust governance systems that can cope with environmental changes and social, demographic and democratic transitions (Adger 2003b). As seen throughout this thesis, resilience and food security are both shaped by change. Yet the ability to promote FPS resilience goals within food policy is dependent on the ability to frame sustainability questions in these terms. A principal reason for policy deficiency is that conceptual development has not kept pace with the speed of changes that alter and control the processes in systems (Gunderson and Pritchard 2002) composed of people and nature, defined as social-ecological systems (Walker et al. 2002) and more specifically, food provision systems. Ideally, the choice of policy-relevant indicator should be made in

collaboration with policy-makers and others, *advancing social cohesion*, who will design and implement the program of intervention (Lundberg and Diskin 1994, OECD 2001, italics added).

The focus in this section is on food security as an objective of both national policy and sustainable FPS. Often the emphasis is on food security at higher-level dissipative structures or the food availability of national FPS. At this macro-scale, however, policy-makers have an opportunity to create aggregate conducive conditions across all scales, e.g. macro-economic conditions. If not properly developed and implemented, what may be a rational and appropriate choice of food policy and FPS at national or global level may have very negative consequences at the local level, as is the case in Belize.

Conversely, individually rational decisions among households may not (in the aggregate) lead to socially or ecologically optimal consequences (Webb 2002). The process of policy-building and improvement is also complex. Lang (2003) identifies public pressure (demand for social cohesion) as one of the main drivers of policy change in the food arena, reflecting concerns about health and the state of the environment. Haddad (2003) similarly identifies seven triggers for public action including social disapproval, mass movements, and interest-group action. In food security planning, policy requires reformulation, while institutions need restructuring (Clay 2003). Thus, the will of such public institutions to address the potential impacts of marginal policy issues may be fostered by the FPS participants concerned with, or affected by, food insecurity (Maxwell and Slater 2003). Public policy must now be developed jointly, furthering social cohesion, through inclusive participation from civil society, business and government,

giving public institutions more legitimacy and authority needed to address food insecurity. In addition, the ability of governments and governance structures to guarantee universal access to FPS wealth is a key element of their effectiveness and legitimacy (Liberatore 2001).

Trust of FPS participants is lost when political institutions fail to address the inter-connectivity of food security (Lang 2003). Trust is the central issue in food policy, it cultivates social cohesion. Broadly, food policy needs to link policy areas that have been dealt with in a disparate manner and to draw upon a new eco-public health paradigm (Barling et al. 2002). This paradigm suggests the need for a significant shift in thinking about food policy, a shift from the current productionist paradigm (McMichael 2001) typified for example, by the Belizean FPS focus on key export commodities. Many forces are at work forming the way FPS participants think and feel about food. Opening up the policy-making process to more varied ideas is necessary, and most urgent for the indigent. Many nations have no established food policies while existing environmental, health, monetary, fiscal or sectoral policies have neglected to include FPS. Moreover, for many nations, agricultural and trade policy is *de facto* their food policy and this has been the case since World War II (Lang and Heasman 2004).

Past decades have witnessed a multitude of approaches to multi-sectoral food security planning and FPS management and there is no scarcity of evaluations offering useful lessons for the future (Field 1987, Maxwell 1997). Yet, FPS management can destroy or build resilience, depending on how the system self-organises in response to management

actions (Carpenter et al. 2001, Holling 2001). There are many examples of management suppressing natural disturbance regimes, or altering slowly changing ecological variables, i.e. changing land potential, leading to disastrous changes in soils, water, landscape configurations, or biodiversity that did not appear until long after the ecosystems were first managed (Holling and Meffe 1996). Similarly, governance can disrupt social memory or remove mechanisms for creative, adaptive response and innovation (growth phase) by FPS participants in ways that lead to the breakdown of systems (McIntosh et al. 2000, Redman 1999), e.g. represented by pathological traps. By contrast, resilience-sensitive management can sustain FPS in the face of surprise, unpredictability, and complexity. Successful FPS management for human well-being (food security), not only requires monitoring, institutional and organisational capacity to respond to feedback and surprises (Berkes and Folke 1998, Danter et al. 2000) but social cohesion and localisation (World Bank 1999) with greater participation of, and planning with, FPS participants at meso and micro-levels.

Few attempts, however, have been made to define social objectives of policies. In this context, Bowler (2002, brackets added) suggests that the social dimension of sustainable FPS include the retention of an optimum level of consumer population, the maintenance of an acceptable livelihood quality, the equitable distribution of wealth from (food system) growth, and the building of (resilience) capacity (in food systems and its components) to participate in the development process, including the use of knowledge to create new choices and options over time (connectivity).

8.2.2 Belize's National Food and Nutrition Security Policy

As demonstrated in Section 6.1.3, the causes of food insecurity in Belize are rooted in the colonial socio-economic systems which have been perpetuated by current modernisation as with other Caribbean nations (Gomes 1985). Vested interests in the conservation phase of the higher-level Belizean FPS have contributed to a focus on limited diversity of commodities, and on constraints of lower-level adaptive cycles. Faced with increasing market liberalisation in Belize, causing imported food to drive down local food prices and thereby eroding the price incentive to local farmers (CSO 2004), a strategy needs to be devised that tends to traditionally-led domestic FPS (Semple and Brierley 2000). Often investments in small-scale and sustainable agriculture offer the largest potential gains to productivity and are effective mechanisms for alleviation of gender inequities (Johns and Sthapit 2004), as argued in Chapter 3 in support of the FPS resilience dimensions.

In the past, Belize's agriculture policy (GoB 2003) maintained a market-led focus while aiming at providing consumers with a nutritious and safe diet at reasonable prices. Agriculture policy was also directed at having an environment within which agriculture could competitively provide products for both domestic food needs, and more significantly, export markets. As a result of this market-led approach, Belize experienced higher levels of national self-sufficiency, development of new export commodities, e.g. papayas and aquaculture; reduced price fluctuations, and growth in export of bananas and citrus products. The aim of this policy is to achieve greater food production capacity within a post-colonial preferential trading system. The policy can also be placed within a dominant paradigm of national wealth creation through international trade. As the context

changes, the dominant trade liberalisation national economic competitiveness paradigm that currently informs food policy and the international levels of the WTO trade rules grants the larger players in the FPS a favoured place in policy-making (Barling et al. 2002).

A socially responsive and sustainable food policy necessitates political mechanisms and processes that can frame policy options in a broader and more integrated fashion than has been achieved by the sectoral agricultural policy. Field research through semi-structured interviews discovered such a shift has occurred in Belize. A shift in emphasis on food availability and trade to a focus on food access and utilisation has led to an alternative combination of policy instruments, i.e. the FNSP (GoB 2001), that can be considered better suited for an integrated food and nutrition security strategy resembling more closely the efforts to achieve FPS resilience and sustainability goals, forming a more coherent, appropriate and integrated food policy.

As stated in the policy document, its mission is to ensure the sustainable supply, accessibility and use of safe, high quality, nutritious, diversified and culturally-acceptable foods for all Belizeans, in order to improve their well-being and quality of life. To do so, organisational arrangements have been set out across many federal departments such as the ministries of Agriculture and Cooperatives; Fisheries; Human Development, Women and Civil Society, Health, and Public Service. Criteria for setting the national food and nutrition security priorities included: (1) cooperation with FPS participants, (2) local communities, (3) targeting the indigent, (4) policy harmonisation, (5) vulnerability to

natural hazards, (6) expected project impacts, and (7) fiscal governance. The policy has six programmatic areas serving as an operational framework to organise projects and activities (Table 8.1) captured by seven policy performance indicators. The first four of the six programmatic areas are directed towards the most affected communities, households and local change agents, while the last two are justified on nation-wide considerations and priorities.

An appraisal of the policy indicators in Table 8.1 reveals that the performance measures address components of all four food security pillars: three on food utilisation (policy indicator 4, 5, 6), two on food availability (1, 2), and one each on access (3) and stability (7). These seven measures address several food insecurity concerns of both major FPS sets of adaptive cycles from exports (2) to staple foods, (1) internalising risks through early warning (7) and food safety (5, 6), to mapping vulnerability (4) and the indigent (3) through nutritional status and food poverty threshold measurements. However, the performance measures address the four FPS resilience dimensions to a lesser degree. Several policy indicators refer to aspects of consumption resilience (4, 5, 6) and economic resilience (3) though the latter falls short by leaving out labour and wealth productivity measurements. Similarly, several aspects of ecological resilience (1, 7, and 5) are included, though greater attention to land potential, cover and use is emphasised. However, social resilience is lacking altogether among all seven policy indicators.

Based on the current indicator make-up, bands of tolerance and resilience thresholds may be preliminarily constructed through food safety and rapid alert systems (5, 6, 7). The

Table 8.1 – Belizean National Food and Nutrition Security Policy Implementation.

Six Programmatic Areas	Target
Information, Education, and Communication on Food Production, Preparation and Nutrition	Directed towards the most affected communities, households and local change agents
Diversified Food Production, Food Processing, Marketing, Storage, and Credit Mobilisation	
Maternal and Child Care, School Feeding and Nutrition for the Elderly and the Indigent	
Creation of Employment and Income Generating Opportunities at the Local Level	
Food Safety	Nation-wide considerations and priorities
Analysis and Reform of National Policies for FNS	
Policy Indicators to Measure Medium and Long-term Performance:	
<ol style="list-style-type: none"> 1. Production and availability of staple food commodities (greater focus on traditionally-led domestic agriculture and lower-level FPS, food availability); 2. Value of food import/export balance (trade/supply, higher-level FPS, food availability); 3. The proportion of population with access to an essential food basket (food poverty threshold, food access); 4. Nutritional status of vulnerable groups (and intra-household allocation, food utilisation); 5. Morbidity and mortality resulting from food and water-borne diseases (food safety, food utilisation); 6. Number of hygienically certified food handling establishments (food safety, food utilisation); and 7. Services from a national FNS rapid alert system and surveillance system (early warning system, monitoring, resilience, stability). 	

surveillance system in (7) must not only respond to (i) natural hazards but include and prepare for impacts from (ii) changes in macro-economic conditions, (iii) the erosion of the country's trade preferential treatment, (iv) changes in community-level food security, and (v) changes in household financial difficulties. The surveillance system can also address FPS resilience concerns of adaptive cycles caught in a pathological trap, once the conservation phase of the highest adaptive cycle has been identified first, as a key aspect in addressing panarchical interactions across Belizean FPS. Lastly, to address FPS resilience more comprehensively, it is critical the FNSP deal with aspects of social resilience to include a policy indicator on safety-nets.

In terms of economic resilience, the solution for the indigent in rural areas lies in employment-intensive development, especially of the small farmer/fisher sector, leading to patterns of rising demand for labour-intensive consumer goods, self-reinforcing growth to conservation phase of lower-level dissipative structures, and rising employment and incomes for previously vulnerable groups within specific adaptive cycles (adapted from Mellor 1988 in Ellis 1992). The current FNSP supports food insecurity alleviation through such improvements in the FPS economic resilience dimension on labour productivity. Sentinels in Belize, such as the indigenous Mayan population in lower-level adaptive cycles, are signalling the Belizean FPS is in peril. As indigenous communities are both sentinels of distress and stewards of wealth (Johns et al. 1994), the fourth FNSP programmatic area, of particular significance to indigenous communities and the indigent in Belize, focuses on the creation of employment and income generating opportunities at the local level, taking into account FPS economic resilience aspects in policy

development, such as diversifying their production, with the incorporation of higher value crops into their FPS, e.g. aquaculture, papaya; or adding value to the crops that they already produce through improvements in quality, presentation and marketing options.

The current FNSP, launched in 2001, has also shifted Belize's policy instruments towards a new paradigm with social cohesion as a means to achieving food security in Belize.

With the addition of a larger ecological resilience dimension, and presence of the social resilience dimension, the FNSP would fit more adequately within a FPS resilience framework. Initial assessments on how the implemented FNSP achieves FPS sustainability goals come from results of the 2002 Poverty Assessment and LSMS (CSO 2004). The survey results show multiple SSC around urban/rural divisions and export/traditional FPS, each with different sets of resilience attributes, e.g. greater weight towards economic resilience factors in urban areas. Close attention to Table 8.1 regarding the six programmatic areas and seven policy indicators further reveals an effort to address the lower-level FPS in Belize. The FNSP does address transient and structural resilience and several forms of wealth. A persistent weakness, however, is the lesser significance and attention given to both ecological wealth (natural, physical and environmental, not solely agricultural), common to food policies (Corral et al. 2000), and social wealth. The latter is very significant for social cohesion (Carter and Castillo 2003, Qadeer and Kumar 2006) and for the role played by safety-nets (Devereux 2000) such as publicly funded transfer programmes with consumption smoothing objectives, education, social networks, or the acquisition of productive wealth. Social resilience alleviates transitory and acute change to livelihoods and plays a significant role in reducing local and community

chronic wealth deprivation and poor connectivity. Although a national policy, the FNSP does attempt to address these local vulnerabilities and scale concerns in Belize, including internalising risks and addressing connectivity. Noteworthy, the FNSP is a good example of institutional organisational capacity in building food policy as social cohesion was achieved to a large extent as the FNSP was developed in consultation with a broad spectrum of food security practitioners including civil society and participants of the lower-level dissipative FPS. Offering hope of better attention to social cohesion in the future is the continued presence of several members on the Food and Nutrition Security Commission who represent the numerous social groups that contributed to the FNSP.

Regarding social resilience, however, additional FNSP support for self-organisation of communities must be given. Consequently, closer attention to community-level FPS resilience mechanisms and the role of cooperatives is also recommended. Investments in FPS resilience development as planned in the FNSP are most effective in achieving community-wide sustainability goals (Anderson and Woodrow 1999, Comfort et al. 1999, Eade 1998). FPS vulnerabilities are often grouped (connectivity), while a meso-scale or regional approach for assessment and response is advocated (Easterling 1997, Schmandt and Clarkson 1992), intermediated by meso-level institutions ranging from local governments to community groups to resource user associations to markets. Thus, targeting the indigent and lowest level adaptive cycles is emphasised. Combined short- to long-term cross-sectoral and cross-scale response packages (Moser 1998) could then focus on these groups through laddered assistance (Kabeer 2001) or decisions prioritised according to need by way of social cohesion.

Finally, Toledo District is the most food insecure region (Table 6.5) and least resilient FPS in absolute terms (c.f. traditionally-led domestic agriculture in Table 7.1). Needed to resolve these vulnerable conditions are national social cohesion on the meaning of food security and FPS development between all Belizeans, the national government, the food industry, and the District's communities. This current negative national institutional setting and insufficient political will towards domestic traditionally-led agriculture, creates discontinuities between adaptive cycles and constrains them in terms of wealth and connectivity. Consequently, food security strategies must be based on community needs, as well as social and cultural wealth and values. This requires facilitating channels of communication between the community, the public sector and the private sector, and adopting greater participatory approaches to intervention than for export-oriented FPS. Noteworthy, investments in social wealth for community networks and cooperatives have been successful in Belize (c.f. Section 7.2.3).

8.3 Chapter Inferences

The FNSP's success will come from further evidence, policy-building and learning. The FNSP is a mechanism that has reached across policy sector barriers by developing a FNSP Commission for driving policy change, providing ministers and the cabinet to a channel for specialised advice around food and nutrition security, and a more structural and strategic level of intervention by scale and dissipative structure. At rural, local and community levels, building resilience capacity allows FPS participants to bring evidence on impacts of food security strategies by participating in the design, monitoring and

evaluation of these initiatives (Glasgow et al. 2002), as rural development is an integral aspect of national FPS development (Gomes 1985).

The FNSP's strong base garners FPS participants' trust in the policy due to social cohesion around food security. Although representation has been achieved, future gains in social cohesion remain as FPS values and food culture between adaptive cycles differ; however, programmes to improve access to quality agricultural land, formal assistance, and promote tolerance may reduce obstacles to social cohesion growth. This FNSP's base must receive continued institutional support. Accordingly, proximity is an important explanation of the approaches adopted by institutions: the degree to which officials are integrated into the local adaptive cycle affects not only their inclination to adopt the strategy but influences the strategy regarding the targeted social group, advancing social cohesion, forming connectivity. In both these ways, food democracy is developed (Hassanein 2003) as the officials and community groups actively participate in shaping the FPS, but also confront its panarchical relationships, i.e. the concentrated economic interests exerted by the higher-level FPS (McMichael 2000). Consequently, food policy that builds on these relationships, and on adaptive cycle-specific diversity and social wealth inherent in FPS, partially achieved by the Belizean FNSP, optimises the chances for the vulnerable and indigent to adapt to changing conditions in a sustainable manner (Johns and Sthapit 2004). If change reduction can be coupled to resilience-sensitive food policies that serve wider development goals, then groups throughout the wealth spectrum and dissipative adaptive cycles will have an opportunity to live with natural hazards, economic and other changes in a more harmonious way.

Chapter 9 – Conclusions

9.1 A Review of the Thesis' Purpose

If a nation is portrayed as generally food secure, and its food provision systems tenable, what of its sub-regions? How do their respective FPS express resilience? Do they receive similar FPS goods and services? How do they adjust to economic wealth depletion, ecological degradation, social decline, or losses in FPS diversity? How do the resilience dimensions relationships coalesce? How are FPS complex and dynamic? What are the linkages among adaptive cycles across scales? Where are FPS participants and resilience components along an adaptive cycle? Do they fall under a pathological trap? And can FPS resilience ensure tenable FPS and long-term food security?

These and other questions can be answered by resilience theory, Panarchy theory and adaptive cycles applied to food provision systems. Based both on promising research results pertaining to resilience theory, and on sparse attempts in the literature to apply resilience to both food security and food systems, this thesis has verified how resilience theory can be developed conceptually and applied experientially to (1) assess and appraise food system dynamics, represented by adaptive cycles and panarchical relationships, and (2) evaluate the extent to which food provision systems can be made more sustainable and food secure in the long-term. This chapter summarise key research features and results by reviewing the tripartite purpose of the thesis exploring and analysing Belizean food provision systems as a case study, represented by two major

distinct sets of adaptive cycles: an export-oriented and traditionally-led domestic FPS, respectively.

The first purpose of the thesis was to conceptual design and research a robust food provision system resilience framework that integrates the relationships of dynamics between social, economic and ecological systems, and providing a more stable foundation for attaining and maintaining food security. Based on this framework, the thesis' second purpose set out to employ Belize as a case study, to appraise current food security levels and to apply the FPS resilience framework at the national and a sub-national level.

Fisheries, agriculture, and related economic sectors, such as manufacturing, based almost entirely on agricultural inputs, continue to be major contributors to the Belize's economic wealth. Until recently, Belize's food and agricultural policy perspectives have clearly delineated between encouraging the export sector while limiting investments in areas of traditionally-led domestic food production. Consequently, the nation's FPS are highly susceptible to natural hazards such as hurricanes and tropical storms, unstable macro-economic conditions, eroding trade preferential treatment of key export commodities, as well as household financial difficulties. In addition, as both of Belize's distinct FPS will be exposed to such multiple stressors, it is appropriate to assess how their respective adaptive cycles might best perform to future change. With these FPS complex vulnerabilities in mind, the third and final purpose of the thesis examines the extent to

which Belize's National Food and Nutrition Security Policy can further support a stable foundation for long-term food security through enhancing FPS resilience.

9.2 Enhancements to Resilience Theory and Implications for Food Provision Systems

FPS, just as their participants, are vulnerable to the adverse consequences of a range of predictable or unanticipated synthetic and natural threats or shocks, change or disturbances. They affect the price and availability of food, access and purchasing power, for safe and nutritious consumption necessary for good health and unimpaired physical work. There are several frameworks which attempt modern views of food systems (Tansey and Worsley 1995). It is quite different, however, to analyse lists of FPS determinants often far too complex to be useful for policy-making (Fraser et al. 2005). Fraser et al. are the first to have conceptually applied Panarchy to FPS on which urban communities depend to help determine future vulnerability. More broadly, the research focus of this thesis was to establish a limited set of resilience dimensions according to the rule of hand, and features of complex FPS that occur as a result of the interactions between fast and slow, large and small adaptive cycles, i.e. panarchical relationships, as FPS are fundamentally non-linear in their dynamics and therefore generate occasional events that challenge policy and institutions (adapted from Holling 2004). Another key aim of the resilience analysis and FPS research of this thesis, corroborated by results from Walker and others (2002), is also to identify thresholds, steady-state conditions, their nature, and the determines on how systems are prevented from moving into an undesirable system configuration or pathological trap.

With regards to thresholds, pathological traps and the crossing of resilience thresholds may be avoided through human innovation that effectively redefines the system by extending the boundaries of the thresholds outward (Walker et al. 2002) or lowering food security thresholds below the adaptive cycle. Time spent in an adaptive cycle foreloop is less germane; it is the shifting of the FPS and corresponding adaptive cycle above the 'food poverty' and 'vulnerability to food insecurity' thresholds that matter. All the same, FPS resilience dimensions contribute the most to long-term food security from the adaptive cycle growth towards conservation phases, and by holding FPS participants at length in that conservation phase where they are the most food secure among of all four adaptive cycle phases.

FPS are complex and diverse. Some FPS participants cultivate food, fish, or herd livestock, while others also take part in non-agricultural activities and labour markets, even migrate or receive remittances. They continuously allocate their available forms of wealth focusing FPS resilience on productive wealth to different FPS goods and services capturing feedback effects within and across adaptive cycles and SSC. As such, the thesis has introduced Panarchy to FPS to bridge ecological, economic, consumption and social linkages between two divergent FPS at separate scales. Segregation of Belizean FPS is also addressed in this thesis as pathological traps focus on chronic food insecurity, the FPS resilience category of greatest concern, not least of which due to the hopelessness it engenders for FPS participants, and the wealth and connectivity polarisation it often reflects, i.e. hierarchical confinement of the lower-level traditional-led domestic

agriculture FPS. As a result, this thesis has shown how a FPS resilience framework allows for a richer description of food security dynamics, replacing conventional methods addressing food security status or outcomes. These results confirm earlier work by Dixit (2003) as the author makes the case that low resilience determines beforehand why some adaptive cycles, i.e. certain sections of society, are more vulnerable to change than others, because of their asymmetric and hierarchal system relationships.

The framework thus addresses many of the moral challenges presented in Chapter 1 that undermine food security and sustainable FPS as shown by the lower-level adaptive cycles in Belize. The various resilience thresholds and dimensions capture the preconditions for attaining minimal basic human needs, balancing wealth and connectivity to achieve food security under any existing or modern arrangement, and in common for future generations. It is more beneficial to the entire FPS that its parts reciprocate social cooperation and cohesion, exploiting resilience for mutual benefit, as demonstrated at the community level among fisher cooperatives in Belize. A coherent, equitable and tenable FPS thus avoids deception, disparities, social exclusion, as demonstrated by the lower-level Belizean FPS, and builds trust and benevolence. The self-organising nature of adaptive cycles in tenable FPS, upheld by SSC and adequate food policies, can thus provide care, food and other system services for the well-being of FPS participants while reducing the potential for food insecure and vulnerable conditions and FPS failures to occur. Tenable FPS exclude chronic unstable macro-economic conditions, vulnerable trade practices and household financial difficulties. However, threats from natural hazards that acutely impact food supplies, access, utilisation and FPS stability, will

require larger investments in FPS wealth, connectivity, diversity and resilience dimensions, geared towards the capacity to manage, adapt to, cope with, or recover from such broad threats.

Panarchical segregation of adaptive cycles will often take integrated interventions at multiple scales to liberate a FPS at lower-levels and related SSC. Any effective strategy to move the system to a new, higher-level SSC, requires both targeted and laddered interventions, and addressing the panarchical relationships between sets of adaptive cycles. Regarding laddered interventions, FPS participants positioned differently around both food security and resilience thresholds may need quite different forms of assistance and FPS goods and services. Accordingly, asset building and safety-nets can provide credible insurance against catastrophic wealth loss, and facilitate resilience in times of change and renewal, and are therefore central to food security strategies.

FPS remembrance or memory, an explanatory strength of Panarchy, gives a bias to the SSC and resilience dimensions that shaped previous adaptive cycles, and maintains the probability of repeating those past cycles as one of the possible options for the future. A major finding of this research is that memory of broader Belizean FPS constrain the shape of smaller structures. Fittingly, memory effectively demonstrated how the food insecure in Belize have remained vulnerable and indigent over time and to this day. Their status is conditioned by the higher-level set of export-oriented adaptive cycles' conservation phase, one in which net growth slows, becomes increasingly interconnected, less flexible, and more vulnerable to external change. These high-level FPS are rigidly

trapped. They command much of the nation's FPS through increased connectivity and weak FPS diversity. To survive they manifestly maintain high resilience. This is contrary to the conservation phase under normal SSC when FPS resilience is low. Such high levels of resilience-stocked wealth is at the expense of all lower FPS, by paying minimal wages for undervalued lower-level FPS labour, developing industries and planted crops upon premier quality lands, by capturing investments favouring the export sector historically, and by receiving priority formal safety-ladder investments following the passage of hurricanes. Such high maintenance costs corroborate Tainter's (2006) findings as they further illustrate the increased FPS complexity and costs in any FPS.

Both Panarchy and the pathological traps perspective emphasise the importance of wealth in a resilience-based approach that focuses on the growth of productive, labour-intensive and capital-intensive wealth. The focus is not just on the availability of wealth but equally on its quality in generating and ensuring FPS resilience. Food security has multi-dimensional causality originating in limited control over a combination of key productive forms of wealth, mainly captured by high-level FPS connectivity. However, increasing labour productivity of the indigent, wealth they already control, is every bit as important as building safety-nets and protecting the stock of productive wealth they own and require. Since the rural poor control mainly labour and less favoured ecological wealth, direct interventions to boost labour and agricultural productivity in such areas as Toledo District will likely improve FPS resilience and food security.

As a result of the discussions on liberating both FPS lower, and higher-level untenable FPS, designing and implementing effective and integrated interventions at multiple scales are required. This involves a bipartite approach to achieving food security, the first on building productive assets and safety-ladders in lower-level adaptive cycles, and the second, addressing the nested set of higher-level adaptive cycles' rigidity by lowering connectivity to reduce resilience and return to normal SSC. Additionally, some forms of wealth are not connected to response capacity, i.e. either unexplored or unaffected by change. Moreover, exploiting all opportunities for mutual gain may in fact reduce resilience, such as acknowledging the need for raising the value and productivity of labour, and sustaining small and traditional farmer/fisher productivity, as well as maintaining SSC, including macro-economic conditions as a precursor to that productivity as they fight against marginal labour productivity declines. Last of all, both investments in integrated interventions around FPS resilience, require innovative food policy reforms, and their inclusion in the Belizean FNSP is recommended.

9.3 Summary

To summarise, this thesis uses Belize's two major food provision systems to demonstrate (1) how repeated acute and chronic changes have resulted in FPS vulnerability to food insecurity, and numerous indigent FPS participants; (2) how their FPS have resulted in adaptive cycle pathological traps; and (3) how resilience theory can provide insight into these positions. Jointly, both the FPS resilience framework and Panarchy have determined why the participants of the lower-level FPS are food insecure, and their FPS vulnerable, i.e. pathologically trapped.

This thesis represents an attempt to link economic, social and ecological systems into a single analytical framework that uncovers roots of food insecurity and vulnerability, particularly regarding the lower-level FPS, currently typified by high intensive wealth activity with little access to larger wealth sources, low connectivity, low resilience, and increased diversity. Conversely, although the higher-level FPS contributes more heavily to the national economy and is perceived as less vulnerable, it too, in fact, demonstrates characteristics of a vulnerable system: its larger amounts of wealth are highly productive though, non-diverse, tightly connected and highly resilient. Connectivity is salient to productivity and wealth concentration. The key here is to focus food policy on managing diverse adaptive cycles, restraining connectivity and redundant wealth, to balance the impact on FPS goods and services on wealth deficiencies and disruptions to food security. It is the combination in which FPS participants engage in Panarchy between their own adaptive cycle, and the other adaptive cycles within Belizean FPS, most significantly the broadest, slowest but highest-level FPS, which will influence their FPS connectivity and wealth strategies for ensuring food security within their respective SSC. Such engagement requires social cohesion across adaptive cycles for attaining sustainable and tenable FPS nationally.

Lastly, the current national Belizean Food and Nutrition Security Policy is a stronger planning tool having shifted away from earlier policies concentrated on food availability towards adaptive management with several economic and consumption resilience components integrated around a process of social cohesion. As is, this food policy is

currently more attuned to the larger deficiencies and disruptions to food security than national food balance sheets, or other tools based on food deprivation, even access-focused availability approaches. Nevertheless, lacking are certain ecological aspects, and the entire social resilience dimension. In addition to current FNSP indicators, this thesis suggests the FNSP integrate land potential, safety-nets, as well as FPS connectivity to its policy gauge.

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APPENDIX A

QUESTIONNAIRE FOR KEY INFORMANT INTERVIEW

NAME: _____ DATE _____
 ORGANIZATION: _____ SCALE/ZONE _____

FIRST SECTION (1/3) – FOOD SECURITY AND POLICY

CURRENT FOOD SECURITY and FOOD PROVISION SYSTEMS

- FAO statistics show undernourishment levels of around 4%. This is well below the Caribbean or Central American average. Why is Belize able to out-perform most other countries in the region?
- What are the major food systems supplying domestic markets in Belize?
- For Belizeans who are food secure, are the majority nationals and immigrants? What are the main causes of food insecurity (e.g. insufficient production, too costly, inadequate transportation/storage, etc.)?
- How does the government go about identifying/defining the food insecure, poor and/or the vulnerable? Where are they?
 - .. identifying/mapping Belize's food system?
 - .. what are current stressors on Belize's food system? Susceptibility?
 - .. prospects +/- over the next 20 years?
 - .. which components at risk to emerging threats/barriers/opportunities?
 - .. How much do these food systems contribute to the economy, e.g. GDP?

Does agri-food production in Belize exceed national demand and if so, the country could play a much larger role in ensuring food security within the Caribbean region, especially if future natural hazards destabilize food production systems elsewhere in the region.

How does Belize see its role in the Caribbean or Central America?

AGRICULTURE & FOOD (INCLUDING MARINE & FISH) POLICY

- What are the main (national, regional) programs/policies that govern agriculture, fisheries, food safety and aquaculture in Belize; what are the issues these policies attempt to address? Are these policies meeting their objectives?

How did the country respond to the 1945 West India Royal Commission Report on Agriculture, Fisheries, Forestry and Veterinary Matters? Does it still influence policy today e.g. agricultural production? (It serves as a basis for appreciating subsequent policies and strategies by which various Caribbean administrations have attempted to increase traditionally-led domestic food production).

RELATED POLICIES

- To what extent (and how) do related policies & programs (i.e. economic, social, development, immigration, tourism, environmental) at all levels either support or undermine food security in Belize? How has the FSNP impacted the food insecure? Formulation, implementation, regulation, monitoring, enforcement, etc.

- Although the focus is at the national level, do you know of any work done at individual, household, community levels or regionally?

SECOND SECTION (2/3) – FOUR RESILIENCE DIMENSIONS

MACRO-ECONOMIC CONDITIONS and HOUSEHOLD EXPENDITURES

What impact does globalisation, current macro-economic conditions and tourism have on levels of food security? How do they affect the vulnerability of food systems? How are the insecure affected? How are households coping with change? Are households meeting their expenses or the cost of food?

TRADE/MARKETS

How do specific exported commodities such as sugar, bananas and citrus, pelagic fish, based on NFBS (FAO balance sheets) contribute to food insecurity?

.. latest WTO DOHA round of negotiations?

How do they affect the vulnerability/resilience of food systems?

ENVIRONMENT

..impact on the environment? Sustainability? e.g. agro-forestry practices.

Impact on coral reef/coastal zone from sea-level rise, loss of biodiversity or natural hazards? Changes in climate, land cover and soils, atmospheric composition, water availability and quality, etc.

HEALTH

What levels of malnutrition have been found in Belize?

What are typical Belizean diets? Diet transition?

IMMIGRATION/SAFETY-NETS

What patterns do Belizeans show seasonally /coping mechanisms to reduce their insecurity? What social programs does the GoB currently offer? Role of cooperatives.

THIRD SECTION (3/3) - FUTURE TRENDS

- In general, what are the major emerging issues that will influence Belize food systems over the next two or three decades?
- What are the future prospects for food security in Belize and what will be the main factors driving food security? Caribbean?
- Given the current policies and programs we have discussed, which one will be able to address these emerging issues? Which one will be inadequate?
- Is global environmental change a factor that needs to be considered in future food security in Belize? How?
- Is tourism/trade/economic globalisation/.. a factor that needs to be considered in future food security in Belize? How?
- Are the institutional structures and policies to address these more complex, in place to address these multiple sets of stressors?

APPENDIX B

KEY INFORMANTS AND INTERVIEW RESPONDENTS

The field interviews conducted for this thesis included members of the National Food and Nutrition Security Commission, other public administrators, members of international organizations, producers, indigenous people and civil society, researchers, traders and businesses and tour operators. Semi-structured interviews employed to discover local knowledge and perspectives regarding FPS resilience, stressors, and food security.

Name	Affiliation and Sector
Dr. Ulric Trotz	Caribbean Community Climate Change Centre
Sergio Garcia	Ministry of Agriculture, Advisor
Salvador Monge	Inter-American Institute for the Co-Operation on Agriculture (IICA) Country Representative
Michael Salton	CARICOM Fisheries Unit
Martin Alegria	Department of the Environment
Lorraine Thompson	Pan-American Health Organization (PAHO), INCAP
Central Statistical Office (CSO),	Ministry of National Development
Rafael Lima, Janelle Rene Ogaldez	
Shaun Finnetty	United Nations Development Programme
Carlos Santos	Integrating Development, Environment and Sustainability (IDEAS), civil society
Melanio Pech	Food and Nutrition Security Commission, Coordinator
Ana Williams	Ministry of Human Development, Women and Children, and Civil Society, Human Development Coordinator
Dr. Jorge Polanco	Ministry of Health
Dr. Michael DeShield	Belize Agricultural Health Authority, Director of Food Safety
Helen Arana	Belize Bureau of Standards, Director (phone telecommunication)
Ricardo Thompson	Ministry of Agriculture, Extension
Jorge Cawich	Centro Agronómico Tropical de Investigación y Enseñanza (CATIE), consultant
Carlos Fuller	National Chief Meteorologist
Jose Castellanos	Ministry of Agriculture, Policy Analyst
Western Dairies, Quality Poultry, Hatchery	Industry, agricultural sector
Oscar Alvarez Gil	Mesoamerican Coral Reef Alliance
Eugene Waight	Ministry of Agriculture, Senior Officer
Filiberto Penados	Agriculture, Indigenous people Toledo District
Glenn Marshall	FAO, Special Programme for Food Security for the Caribbean. Based in Trinidad and Tobago on mission to Belize
Isaias Majil	Fisheries Department, Marine Protected Areas
Also met informally with independent tour and lodging operators, the Ministry of Immigration, workers at Central Farm (Research and Extension), Central Bank, traders and small-scale farmers, researchers at the University of Belize (Central Campus), and Taiwanese shop-keepers.	

APPENDIX C

FOOD SECURITY CHANGE FACTORS AT THE SUB-NATIONAL SCALE

<p>Availability</p> <ul style="list-style-type: none"> -Concentration capital intensive agriculture towards large scale farmers; -Low labour productivity, low yields in small-scale agriculture, lack of drainage/irrigation, outdated farming practices or equipment; -Little employment for small scale farmers although some are shifting to aquaculture, fishing, tourism though earnings are up, yet poverty stays the same; -Inadequate/inappropriate credit and other inputs; -Over-fertilization, contamination worries; -Loan delinquency, illegal/ foreign fishing, financial mismanagement/disloyalty; -Tilapia: Introduction of new species suppressing local indigenous species and native fish. Loss of some biodiversity. Variable threat as new economic opportunity and food choice and growing in common diet; -Lack of local entrepreneurship. 	<p>Responses in Effect, Needed or Proposed</p> <ul style="list-style-type: none"> -FNS Policy Programmatic Area 2: Diversified Food Production, Food Processing, Marketing, Storage, and Credit Mobilization: Credit put into effect through small farmers business bank and other projects; -Water legislation enforcement needed; -Fisheries cooperative strong model; -Farm shrimp and tilapia policies lagging behind as no control over spread nor aquaculture production sufficient; -Shifting diversification achieved, production up, areas up, thanks to past 1997 food and agriculture policy, gains in competitiveness and productivity remain; -Business development and training a must for entrepreneurship.
<p>Access</p> <ul style="list-style-type: none"> Cost of living expensive, high poverty, no purchasing power, no decline in unemployment; -Rural/urban divide; -Belizean cultural tendency to over-borrow seen from the citizen to parliament (Creole most affected) -Eroding small-holder viability, livelihood and food sovereignty, improved varieties not working, need to readopt indigenous crops; -Too dependent on imports, a shift away from wheat?; -Gender, empowerment, intra-household allocation issues. 	<ul style="list-style-type: none"> -FNS Policy Programmatic Area 4: Creation of Employment and Income Generating Opportunities at the Local Level; -Women's issues not sufficiently supported; -Must adopt pro-poor growth, asset building, support social institutions; -Import substitution away from wheat towards rice, maize and sorghum possible; -Need to consider indigenous knowledge contribution to food security.
<p>Utilisation</p> <ul style="list-style-type: none"> -Breastfeeding practice high; -Food preparation not well known; -Food handlers have certificates but not well enough trained in food safety measures, perceptions of local food quality low; -Higher socio-economic status modifies food choices towards higher protein-rich foods but also unhealthy foods; -Ethnicity and cultural foods shifting; -Affordability and access to formal education and health care more difficult. 	<ul style="list-style-type: none"> -FNS Policy Programmatic Area 1: Information, Education, and Communication on Food Production, Preparation and Nutrition; and Area 3: Maternal and Child Care, School Feeding and Nutrition for the Elderly and the Indigent. -Support increasing State expenditure on education and health care; -Invest in safety-net measures, and asset building.

FNS Policy Programmatic Areas: These are part of the current GoB's Food and Nutrition Security Policy. See Table 8.1 for additional details on the FNSP.

APPENDIX D
NATIONAL FOOD SECURITY CONCERNS AND ISSUES IN BELIZE

<p>Availability</p> <ul style="list-style-type: none"> -Production years always changing; -Long-term sustainability of capture fishery, reliable/competitive seed stock and animal feed, loss production due to diseases; -Food safety levels improving, maintaining plant/animal health status, inadequate packaging, regulatory grades and standards; -Limited government land available for agriculture and land tenure insecurity; -Inadequate infrastructure: roads, markets, health; -Natural resource management threatened, e.g. citrus input runoff into water; -Water privatization risk; Is public good; -Training/extension weak, little investment in research and development; -Increased cruise-ship tourism; -Lack of storage, post-harvest losses high; -Developing organic produce. 	<p>Responses in Effect, Needed or Proposed</p> <ul style="list-style-type: none"> -Belize Agricultural Health Authority (BAHA) instituted on food safety: providing national standards, developing surveillance, training and certifying food handlers, educating and creating awareness of food quality issues, food-borne illnesses and so forth; -Increase agro-processing and linkage to the tourist industry; -Right to food essential, land tenure reform necessary; -Further legislation required regarding water, building upon existing regulations; -Tourism seen as domestic 'export' market, policy leaning towards import substitution for foodstuffs demanded by tourism industry; and -Having organic district would bring great value added and niche market opportunities. Study required.
<p>Access</p> <ul style="list-style-type: none"> -Poverty increasing, high; -Poor infrastructure: Distribution, production costly, fuel costs expensive; -Imports costly; -Population growth, increase in demand, markets expanding; -Little market information available for producers and traders; -Only agriculture sector with macro-economic vision. -Agricultural cooperative viability; -Remittances leaving country to neighbouring nations depending on ethnicity; labour force too expensive, immigrants at lower wages working in agriculture. 	<ul style="list-style-type: none"> -Current 2006 Budget less pro-poor oriented, need economic growth geared towards poverty reduction, government not investing in revenue generating activities sufficiently; -Must adopt pro-poor growth, not aim for big projects (e.g. dam) but favouring asset building by the poor and indigent; -Population growth high, over 45 000 in last six years. Face of Belize and food system changing. Unsure if prepared for increased food demand; -Investments required in market information systems, transportation networks/roads; -Macro-economic environment unhealthy. Fiscal and monetary reform needed; and -Need to address consequence of concentration in agriculture – what of the small-scale farmers?
<p>Utilisation</p> <ul style="list-style-type: none"> -Food policies weak; -Nutritionists not represented in government; Nutritional surveillance needed; -Nutrition weakest program in health department; -Social security, pension funds, safety-nets problematic, costly to obtain, criteria a concern; -Food-borne diseases under-reported; -Healthier populations contribute to economy, macro-economic costs to country as illnesses lower productivity; -Water security/sanitation need investment. 	<ul style="list-style-type: none"> -FNS Policy Programmatic Area 5: Food safety; -Past focus on availability overemphasized – access and utilization priority issues; -Nutrition currently low priority; -Social reform needed; -With new habits of eating out over the last five years, cases of chronic and infectious illnesses up, numbers unknown; and -Further assistance to BAHA and public health required.

APPENDIX E

REGIONAL FACTORS AFFECTING FOOD SECURITY IN BELIZE

<p>Availability</p> <ul style="list-style-type: none"> -Natural hazards such as hurricanes, tropical storms, sea-level rise, climate change, loss of habitat; - Exports favoured over domestic production; -Healthy mangroves, good reef production; and -Fisheries coops pro-active in sustainability, leaders. 	<p>Response in Effect, Needed or Proposed</p> <ul style="list-style-type: none"> -National Emergency Management Organization (NEMO), emergency preparedness; Best agro-meteorological service in the region; most progress in environmental management in the region; strong legislation though weaker enforcement; and -Strong environmental policies and regulation, not enough funding for enforcement, research and development, training.
<p>Access</p> <ul style="list-style-type: none"> -Globalization, trade, loss of preferential market access for sugar and bananas; -Regional poverty; -Free labour access within Caribbean single market; and -Market underdeveloped and saturated for current commodities locally and CARICOM. 	<ul style="list-style-type: none"> -Plan Puebla Panama – regional poverty reduction strategies; -2003 Food and Agriculture Policy; -Central American trade arrangements needed/being pursued away from Caribbean; and -Liberalization good if properly managed, i.e. protection from supply shocks.
<p>Utilisation</p> <ul style="list-style-type: none"> -Nutrition-related non-communicable diseases on the rise; -Food safety issues; -Biotechnology and GMOs. 	<ul style="list-style-type: none"> -Learn from other nations, international organizations, stakeholders and partners; -Take part in discussions; and -Most issues not debated generally.

APPENDIX F

GLOSSARY

Adaptive cycles – Over time, the structures and functions of systems change as a result of internal dynamics and external influences, result in four characteristic phases which constitute the adaptive cycle. They are growth, conservation, release and reorganisation. As adaptive cycles are subject to small constant changes and large acute changes, they must continuously fight to maintain system services and functionality through the aid of homeostatic mechanisms.

Band of tolerance – Resilience is a dynamic readjusting pattern that is characterised by multiple directions and magnitudes, as it changes with transformations to and within the adaptive cycle. Steady-state conditions within these changing levels of resilience fading and increasing, fall within upper and lower thresholds of the resilience band.

Change - Defined as growth, transformation and stability along a food system's adaptive cycle.

Connectivity – Low connectivity is associated with diffuse elements loosely connected to each other whose behaviour is dominated by outward relations and affected by outside variability. High connectivity is associated with the concentration of system components whose behaviour is dominated by inward relations among components, relations that control or mediate the influence of external variability.

Conservation phase – As structure and connections among system components increase, more resources and energy are required to maintain them. The second phase of the foreloop is one in which net growth slows and the system becomes increasingly interconnected, less flexible, and more vulnerable to external change. This is described as the conservation (K) phase. These two phases, r and K, called the foreloop, correspond to ecological succession in ecosystems and constitute a development mode in organisations and societies.

Dissipative change - Food systems exhibit economic, ecological and social thresholds that, when exceeded, result in changes in food system properties and services, thus impacting sustainability and levels of food security. The system is said to have undergone a dissipative change. The more resilient a food system, the larger the disturbance it can absorb without shifting into a new dissipative state. Dissipative change represents an entire shift of the adaptive cycle, an entirely novel self-organising system.

Diversity - Diversity provides a way of assessing the capacity of a system to adapt to external forces as diverse systems are better able to tolerate a wide range of environmental, economic, and social conditions than simple systems.

Food access – Access refers to the ability to secure food, e.g. from the market, and to means of production. Purchasing power is critical to food access and this varies in relation to market integration, price policies, and temporal market conditions. By way of purchasing power and affordability in the market, or own production (with access to inputs, land, credit, technology), food access is necessary for achieving food security but not a sufficient condition for realising food utilisation.

Food availability - Food availability is derived from agricultural production, e.g. from cash crops, livestock, fishing and forestry as well as food cultivation, ideally by means of a sustainable use of natural resources. The availability of food is a function of domestic production enhanced by net food trade, i.e. commercial imports and food aid minus exports, processing and losses. It is made up of supply, e.g. agricultural output, fisheries, imports, aid, gifts and exchanges; and harvesting, processing, storage and distribution. Food availability is necessary to ensure food security but not a sufficient condition for attaining food access.

Food provision system (FPS) – Systems are a means of conceptualising the relationships among different forces acting upon flows between factors. FPS include services such as agricultural and marine breeding and production; processing, packaging, and the distribution of food; preparation and consumption; and food-related waste disposal and recycling. These food system services, depicted (see Figure 1.1), follow a cyclical pattern situated within layered ecological, social and economic wealth, as well as factors of resilience, i.e. the adaptive cycle, steady-state conditions, homeostatic mechanisms and the resilience threshold. Adding ‘provision’ to food systems underscores how the latter are ill-structured for ensuring food security as the FPS participants have many competing purposes and priorities, while food system participants exercise leverage over food system sustainability, restructuring, transforming or destructing FPS. It is necessary to follow food provision from the producer to the consumer which has more recently been portrayed as land to lip (Fine 2002), plough to plate, and fin to fork. Food systems are thus composed of sequential processes: from production, through exchange, and distribution, to consumption and waste; and non-linear components such as actors, agents, inputs, demand, policies and regulations who drive these processes. Both processes and non-linear components are part of FPS. In combination, they provide four food groups: non-staple nutritional foods, staples not consumed directly, industrial crops and non-nutritional foodstuffs (Cannon 2002). FPS are made up of providers at each process of said systems: producers are provided with inputs to provide food for own consumption and for transfer informally or through the market at which point, traders, wholesalers and retailers provide, transport, distribute and exchange food to consumers who provide, select and prepare food for own consumption and their families, who in turn, provide information, signals, and feedback along the system regarding their choices in provision, while governments have the responsibility to provide regulations and monitor the provision of food at the various levels of the systems including waste and recycling.

Food security –According to a currently accepted definition agreed upon at the 1996 World Food Summit (FAO 1996), food security is achieved when it is ensured that all

people, at all times, have physical, social and economic access to sufficient, safe and nutritious food which meets their dietary needs and food preferences for an active and healthy life.

Food utilisation - Utilisation refers to food preference influenced by culture, food safety, food quality, health status and patterns of consumption. This requires a healthy resource base such as safe water and sanitation. However, food utilisation may not fully lead to nutrition security, e.g. inadequate energy, protein and micronutrient intake. As a result, the food insecure are malnourished at one extreme and suffering from nutrition-related non-communicable diseases at the other, e.g. obesity, diabetes.

Growth phase - r phase, characterised by readily available resources, the accumulation of structure, and high resilience, i.e. greater food system ability to resist change, maintain food system properties and services. It is the first phase of the foreloop, along with conservation, corresponding to ecological succession in ecosystems and constitutes a development mode in organisations and societies.

Homeostatic mechanisms – Food systems within SSC have mechanisms of response to change, generating internal forces or resilience opposing and adapting to change, called homeostatic mechanisms (Garcia 1984). These forces are responsible for system stability, maintaining food system services and the capacity to remain within SSC. Increased or amplified changes to functional components may push them beyond a certain threshold, outside its resilience band, and take the food system and thus the adaptive cycle away from SSC.

Indigent - Their poverty levels are based upon a food basket providing a minimum level of dietary energy, excluding non-food items. Persons with income below this food poverty line, cannot afford the food basket and are called the indigent, a sub-set of overall poverty, also called the food poor, income poor, or extreme poor.

Panarchy – Adaptive cycles and food provision system processes are linked across scales based on the interactions between two sets of adaptive cycles: (1) higher-level, broader but slower structures and processes, and (2) lower-level structures and processes that are faster and smaller. These interactions between sets of adaptive cycles can be characterised as either hierarchical confinement or panarchical relations. Panarchy Theory (Gunderson and Holling 2002) is known as a subset of resilience theory applied to cross-scale relationships between adaptive cycles and dissipative states. Panarchical relations suggest that both top-down and bottom-up interactions occur while hierarchical confinement is demonstrated when slow, broad features constrain and shape the smaller, faster structures

Pathological states – Pathological traps can take on four combinations of adaptive cycle properties (wealth, connectivity, and resilience) having deviated from normal food system flows and conditions. They are departures from the adaptive cycle and are nested in a poverty, rigidity, lock-in, or structural trap. They are undesirable.

Release phase – Disturbances in the conservation (K) phase and the crossing of thresholds lead to this phase, a period of release (Ω) of bound-up resources in which the accumulated structure collapses. With the reorganisation phase, these two phases, Ω and α , are referred to as the backloop.

Reorganisation phase – This (α) phase, in which novelty can take hold, leads eventually to another growth phase in a new adaptive cycle. The new growth phase may be very similar to the previous growth phase, or it may be quite different. With the release phase, these two phases, Ω and α , are referred to as the backloop.

Resilience (generic) - Resilience is the capacity of a system to experience change while retaining essentially the same function, structure, feedbacks, and therefore identity (Walker et al. 2006), e.g. food provision system properties and services.

Resilience (food system) - Food system resilience is process-driven, dynamic and strives to maintain food system functionality and therefore, food security outcomes. Food system resilience lessens acute, transitional, seasonal, cyclical and chronic variations in food consumption, access and availability, as well as longer-term efforts to preserve stability and means of production.

Resilience (consumption) - Consumption resilience (outcome dimension) is distinct from the other three FPS resilience dimensions (processes). It is a cornerstone of FPS resilience as nutritional status indicates place along the adaptive cycle and food regime level in which the individual participates in FPS. Some individuals and household members are food insecure in households enjoying food security. Conversely, certain individuals are well nourished even in households that are food insecure overall. Measurement of individual food security, whose access to food is regulated by intra-household allocation rules and processes, requires measurement of individual food utilisation, the third pillar of food security. This measurement is of particular relevance in selecting food poverty thresholds for analysis to distinguish between the food secure, the vulnerable to food insecurity, and the food insecure.

Resilience (ecological) – Ecological resilience (slow dimension) denotes land-change use in physical and natural wealth, effectiveness in terms of resource utilisation and waste minimisation, its ability to support social and economic resilience, as well as food utilisation, without undermining ecological conditions and the natural ecosystems in which it operates. Food availability is largely coupled to this base.

Resilience (economical) – Economic resilience (fast dimension) symbolises the financial wealth of the system, economic growth and diversity in which it operates, the food provision chain that it rests on, its labour and capital productivity, and increasing incomes over time and the markets that it serves. Food access is mainly tied to this resilience dimension.

Resilience (social) - Social resilience (mixed slow/fast dimension) is designated as human, political, and cultural wealth of the system, including safety-nets, levels of

education, institutional stability, social cohesion regarding FPS objectives, and both the political and cultural cohesion and enhancements of the standard of living of its host societies. This fourth resilience dimension is linked to the food security pillar regarding stability.

Resilience (threshold) – Upper and lower food system resilience limits of the band of tolerance. Area within the band and thresholds are represented by SSC.

Rule of Hand - An empirical claim associated with the adaptive cycle model is the ‘rule of hand’ (Gunderson and Holling 2002), which states that for most systems, the adaptive cycle can be adequately modeled by a small number of approximately three to five key variables, the dynamics of which may occur at different time scales. As food security is defined as having four distinct pillars, i.e. food availability, food access, food utilisation and stability, and in respecting the conditions set out by the rule of hand, the research proposed here has assigned to each of these four pillars, four resilience dimensions, one to each of the pillars. They are ecological resilience, economic resilience, consumption resilience, and social resilience, respectively.

Self-organisation – Resilience of a system requires some capacity for memory, which enables it to be self-organising and return to a steady state. Adaptive cycles at one level can be repeated if higher-level adaptive cycles of the Panarchy provide memory, and the role of memory is strongest when the higher-level adaptive cycle is in the conservation (K) phase. Such Panarchical linkages across scales between sets of adaptive cycles provide opportunities for memory from the higher-level adaptive cycles to influence and renew lower-level adaptive cycles, and facilitate or inhibit innovation and adaptive cycle configurations. For instance, dissipative adaptive cycles can emerge when memory is disrupted because higher-level adaptive cycles are themselves in a backloop, or even in an early growth phase (r), with many system trajectories still possible (adapted from Walker et al. 2006).

Social cohesion - Social cohesion is a comprehensive concept including political, social, economic and ecological integration (adapted from Qadeer and Kumar 2006). It is the degree of panarchical segregation and adaptive cycle discontinuities in the Panarchy that are indicative of social cohesion. Once social cohesion is achieved, social relations are strengthened through ladderred FPS safety-nets, i.e. sequential mechanisms of FPS resilience-sensitive food security interventions supported through social consensus.

Stability – Stability is the fourth and most recent food security pillar. This pillar overreaches the first three food security pillars (availability, access and utilisation), and can either disrupt or facilitate their attainment, not only food availability or the food supply.

Steady-state conditions – Given any previous state, the structural properties of a given food system (adaptive cycle) tend to evolve towards steady-state conditions (SSC). The adaptive cycle configuration and its properties do not change with time, within normal conditions (Garcia 1984, italics added), that is, the food system maintains its functions,

services and structure. This follows Holling's (1973) notion of resilience as the amount of disturbance a system can absorb without shifting into an alternate self-organised system. If a disturbance is large enough, however, an adaptive cycle may cross over resilience thresholds, departing from normal SSC.

Sustainability – It is the capacity to continue a desired condition or process within a dynamic, evolving system, e.g. the food system's desired process or sustainable goal is to ensure food security. Sustainable food system services thus ensure food security and foster equity.

Vulnerability to food insecurity – It is the susceptibility to future harm from the outcome of food system changes (in terms of an unfavourable future outcome). Vulnerability is defined relative to the negative outcome of food insecurity and refers to food system participant's propensity to fall, or stay, below a food security threshold within a certain time frame. It is the space between the probability of becoming food secure and a predefined food poverty line. Vulnerability is relative to a social welfare outcome (food security).

Wealth - Wealth is inherent in the accumulated adaptive cycle and includes (1) economic wealth, e.g. monetary, assets/entitlements, labour; (2) social wealth, e.g. political and cultural; and (3) ecological wealth, e.g. physical, natural wealth. The difference in wealth activity in the adaptive cycle varies as with decreasing absolute wealth, wealth activity intensifies.

APPENDIX G

ACRONYMS

BAHA – Belize Agricultural Health Authority
CSO – Belizean Central Statistical Office
CARDI – Caribbean Agricultural Research Development Institute
CARICOM – Caribbean Community and Common Market
CATIE – Centro Agronómico Tropical de Investigación y Enseñanza
CFNI - Caribbean Food and Nutrition Institute
CFSAMs - Crop and Food Supply Assessment Missions
CH - Analytical challenges
DES – Dietary Energy Supply
DFC - Development Finance Corporation
ECLAC - Comisión Económica para América Latina y el Caribe
EL - Actions to meet analytical challenges, CH
EU – European Union
FAO – United Nations Food and Agriculture Organisation
FP1, FP2, FP3 – Food poverty lines
FPS – Food Provision System
FNSP - Belizean Food and Nutrition Security Policy
GDP – Gross domestic product
GoB – Government of Belize
IICA – Inter-American Institute for the Cooperation on Agriculture
INCAP - Instituto de Nutrición de Centro América y Panamá
IFPRI – International Food Policy Research Institute
LSMS - Living Standard Measurement Survey
NEMO – Belizean National Emergency Management Organisation
NFBS - National food balance sheets
RO – Research objective
PAHO – Pan American Health Organisation
SSC – Stable-state conditions
UNDP – United Nations Development Programme
UNICEF – United Nations Children’s Fund
WFP – United Nations World Food Programme
WTO – World Trade Organisation