

Chapter 9

Dynamics of Social–Ecological Systems: The Case of Farmers’ Food Security in the Semi-arid Tropics

Chieko Umetsu, Thamana Lekprichakul, Takeshi Sakurai, Taro Yamauchi,
Yudai Ishimoto, and Hidetoshi Miyazaki

Abstract Resilience is defined as “the capacity of a system to experience shocks while retaining essentially the same function, structure, feedbacks, and therefore identity (Walker et al. (2004) *Ecol Soc* 9(2):5). Although resilience has been defined and analyzed in ecological as well as social-ecological terms, their method of analysis is still under development. Recently, the concept of resilience has been directly applied to regional development and food security issues where people’s livelihoods rely heavily on the natural resource base. Resilience of social-ecological system (SES) is considered an important component for achieving sustainability.

Within Semi-Arid Tropical Sub-Saharan Africa, communities’ livelihoods depend critically on fragile and poorly endowed natural resources, and poverty and environmental degradation are widespread. People in these regions depend largely on rain-fed agriculture, and their livelihoods are vulnerable to environmental variability. Environmental resources such as vegetation and soil are also vulnerable to human activities. To surmount these environmental challenges, human society and ecosystems must have a capacity to recover quickly from environmental shock.

We argue that, in order to operationalize resilience, it is important for us to consider *resilience* in the context of human security of rural households in semi-arid tropics (SAT) regions. We consider resilience *to* environmental variability, such as

C. Umetsu (✉)
Research Institute for Humanity and Nature, Kyoto, Japan

Nagasaki University, Nagasaki, Japan
e-mail: umetsu@nagasaki-u.ac.jp; umetsu@chikyu.ac.jp

T. Lekprichakul • Y. Ishimoto • H. Miyazaki
Research Institute for Humanity and Nature, Kyoto, Japan

T. Sakurai
Hitotsubashi University, Tokyo, Japan

T. Yamauchi
Hokkaido University, Sapporo, Japan

drought, flooding, and social changes. We consider resilience *of* food supply and consumption, health status, agricultural production, and livelihoods. Lastly, we consider resilience *for* protecting human security, i.e., survival, livelihoods, and dignity. The purpose of the chapter is to show our empirical evidence from Zambia and the dynamics of farmers' livelihoods in response to various shocks, discuss whether threshold can be defined in the context of food security in social-ecological system, and, lastly, investigate the role of institutions to build adaptive capacity of the communities.

Keywords Adaptive capacity • Agricultural system • Environmental shock • Food security • Resilience

9.1 Introduction

Resilience is defined as “the capacity of a system to experience shocks while retaining essentially the same function, structure, feedbacks, and therefore identity” (Walker et al. 2004, 2006a). Resilience, in other words, refers to the largest amount of disturbance that a system can endure without changing the original steady state and without moving into an alternate regime. The social-ecological system, which is an important system for considering resilience, has a certain threshold. Once the threshold is crossed, leading to cascading changes, some systems are able to respond to disturbances by maintaining a reversible regime shift over time, but other regime shifts are irreversible. A system is said to be more resilient if it has the ability to absorb larger disturbances without moving into an alternate regime.

The concept of ecological resilience has been a focus of ecological research since it was defined in the seminal paper “Resilience and Stability of Ecological Systems” by Holling (1973). The earlier concept of resilience was called *engineering resilience*, where resilience is defined as the recovery time of an ecological system to the pre-disturbance equilibrium condition. The shorter the return time, the greater the resilience of the ecological system. The equilibrium concept was expanded to the concept of *ecological resilience*, which emphasizes the capacity to endure disturbance, incorporating non-linearity, multiple equilibrium, and regime shifts. After the 1990s, the resilience concept focused more on the self-reorganizing properties after the disturbance. Recently, researchers applied the resilience concepts used in ecology and engineering to complex social–ecological systems (Levin et al. 1998; Levin 1999; Berkes and Folke 1998; Berkes et al. 2003; Gunderson 2003; Gunderson et al. 2006). Resilience is an especially relevant concept for considering the recovery of disaster-affected communities and the development of rural societies, where livelihoods are highly dependent on a natural resource base.

The development of the ecological resilience theory occurred in parallel with the emergence of the field of ecological economics, which was established in the late 1980s. Ecological economics arose mainly in the developed world and focused less on critical development issues such as poverty and environmental degradation. In contrast, conventional development economics ignored ecosystem services

which form the basis of human economic activity. There was thus a need to link socio-economic research with ecological research and to apply the resilience concept in social–ecological systems to address development issues such as resource degradation and enhance human security. To monitor and manage resilience, it is necessary to understand how the system adapts to different disturbances and system properties in terms of its buffer stock or redundancy, flexibility, margin to its threshold, and system tolerance when approaching the boundary. Although attempts have been made to analyse resilience both as an ecological system and an integrated social-ecological system (Holling 1973; Folke 2006), the method of resilience analysis is still under development. Recently, the concept of resilience has been directly applied to regional development and food security issues in a setting where people’s livelihoods rely heavily on the natural resource base (Perrings 2006; Mäler 2008; WRI 2008; ICRISAT 2010; Umetsu 2011). Resilience of the social-ecological system (SES) is considered an important component for achieving sustainability (ICSU 2010).

Within the semi-arid tropics (SAT) of Sub-Saharan Africa, food security, livelihood resilience, and poverty reduction are critical development issues. People’s livelihoods critically depend on fragile and poorly endowed natural resources, and poverty and environmental degradation are widespread. Agricultural systems in these regions are largely rain-fed, and people’s livelihoods are vulnerable to environmental variability. Environmental resources such as vegetation and soil are also vulnerable to human activities. To surmount these environmental challenges, human society and ecosystems must strengthen their capacity to recover from environmental shocks quickly.

To operationalize resilience research, the concept must be contextualized by clearly defining resilience of what, resilience to what, and resilience for what or for whom in the examination (Walker et al. 2006a, b). We argue that with rising population, depletion of natural resources, degradation of the natural environment, and increased climate variability, human insecurity in general and food insecurity in particular of rural households in the SAT region is a high-priority development challenge to be collectively addressed by local governments and international communities. We consider the resilience *of* food supply and consumption, health status, agricultural production, and livelihoods; resilience *to* environmental variability, such as drought, flood, and social changes; and resilience *for* protecting human security, which has three pillars, i.e., survival, livelihood, and dignity.

The purpose of this chapter is to show our empirical evidence from Zambia and the dynamics of farmers’ livelihoods in response to various shocks. First, we describe the social-ecological system in the context of food security in the SAT. Next, we show some examples of the quasi-threshold to food insecurity in the social-ecological system and discuss whether the threshold can be defined. Quasi-threshold is used to mean that crossing the limit does not necessarily move the system to another regime. Then we analyze resilience indicators for assessing general resilience for monitoring and management purposes. Finally, we provide policy implications for enhancing resilience for food security. The role of institutions to build adaptive capacity is also discussed.

9.2 Social–Ecological Systems and Food Security in the SAT

The SAT is located in 48 countries across four continents, covering 22.6 billion km² and 15.2 % of land area. In Sub-Saharan Africa, including the southern belt south of the Sahara desert, the SAT region covers most of eastern and south-central Africa. The ecologically oriented definition of SAT was suggested by Troll (1965). He considered the length of the dry season, the length and quality of the wet season, and rainfall adequacy to meet evapotranspiration needs; thus, this definition is oriented to agronomic management. The wet season includes the months when the amount of rainfall exceeds the maximum possible evapotranspiration. According to Troll’s definition, the SAT is a tropical region with a wet season of 2–7 months and dry season of 5–10 months. Recently, Ryan and Spencer (2001) defined SAT as follows: (1) length of the growing period is 75–180 days, (2) mean monthly temperature for all months exceeds 18 °C, and (3) daily mean temperature during the growing period is above 20 °C. In the SAT region, the livelihoods of communities critically depend on fragile and poorly endowed natural resources, and poverty and environmental degradation are widespread. People in these regions largely depend on rain-fed agriculture, and their livelihoods are vulnerable to environmental variability.

In the case of an emergency such as drought or flood, the most important mission for households and communities is to secure the food supply for survival. Figure 9.1 shows the social-ecological system of our study, which was adopted by the Research Institute for Humanity and Nature (RIHN) Social-Ecological Resilience

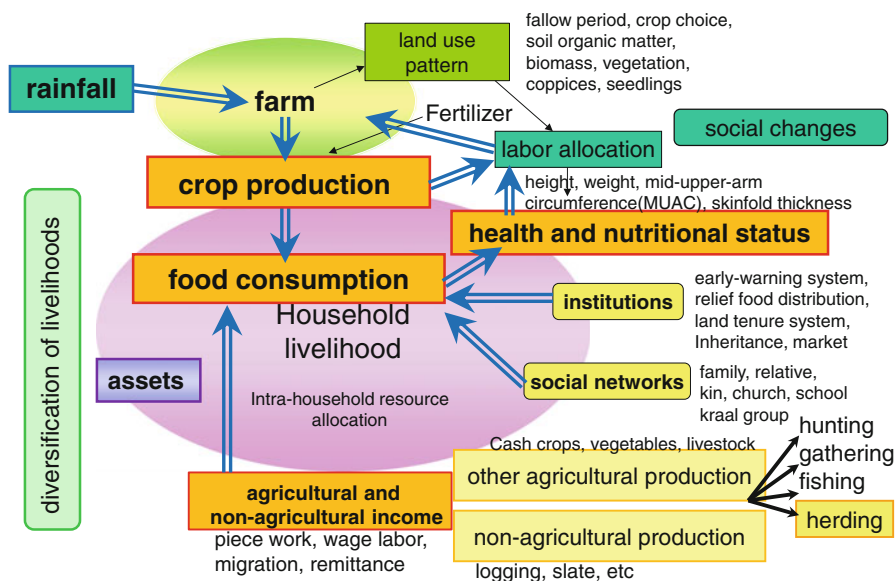


Fig. 9.1 Factors affecting resilience for food consumption levels among farm households in Zambia

Table 9.1 Concepts of resilience: from a narrow to a wide perspective

Resilience concept	Characteristic	Focus	
Engineering resilience	Return time, speed	Recovery	Short run
Ecological system resilience/social resilience	Buffer capacity	Robustness	Short run
Social-ecological resilience	Reorganization	Adaptive capacity, transformability, learning, reorganization	Short run and long run

From Folke (2006)

Project (Vulnerability and Resilience of Social–Ecological Systems) conducted from 2006 to 2011 (Umetsu 2011). This diagram indicates our research components, indicators, and factors affecting resilience and illustrates the linkage between rainfall, food supply, food consumption, health, and ecosystem services in drought-prone areas. Environmental variability such as rainfall and social changes (resilience *to* what) is shown in blue. Indicators are food supply, food consumption, food production, and health status (resilience *of* what) and are shown in orange. The connecting arrows show the working hypothesis of the project. Our purpose is to investigate the strength and weakness of the connection between these components, test the indicators of resilience, and verify factors and conditions for resilience.

Folke (2006) summarizes the concepts of resilience from a narrow to a wide perspective (Table 9.1). Engineering resilience is characterized by return time and speed. The focus of engineering resilience is recovery after disturbance of the system, whereas the main characteristics of ecological and social resilience are buffer capacity and robustness. The most recent and newly emerging concept of social-ecological resilience is characterized by reorganization and focuses on adaptive capacity, transformability, learning, and innovation. The engineering resilience of food security, the speed of recovery of food consumption, is reported in detail in Sakurai et al. (2011a, b), and the robustness of agro-ecological systems is reported in Shinjo et al. (2011). In this chapter we focus more on the recovery and adaptive capacity of social–ecological systems for food security.

Our three field sites were located in the Sinazongwe and Choma districts, Southern Province, Zambia (Fig. 9.2). The people in our sample villages are called Valley Tonga. After construction of the Kariba Dam in 1959, the Valley Tonga people suffered huge social and political shocks because of forced relocation from the valley bottom to the hill area (Colson 1960; Scudder 1962, 2010; Cliggett 2005). Site A (altitude 500 m) is close to Kariba Lake in an area of flat land; an old village was present before the dam was constructed, and the new village was relocated to site A after dam construction. Site B (altitude 700 m) is located in a mid-escarpment area with hilly farmlands. Residents of Site B were relocated to the current location during the 1990s. Site C is located at the highest altitude (1,050 m), at the edge of a plateau, and is an old village that existed before dam construction.

An intensive household survey was conducted to collect data; 16 sample farmers were selected from each site (A, B, and C). A total of 48 farm households were interviewed during the three cropping seasons, 2007/2008, 2008/2009, and 2009/2010.

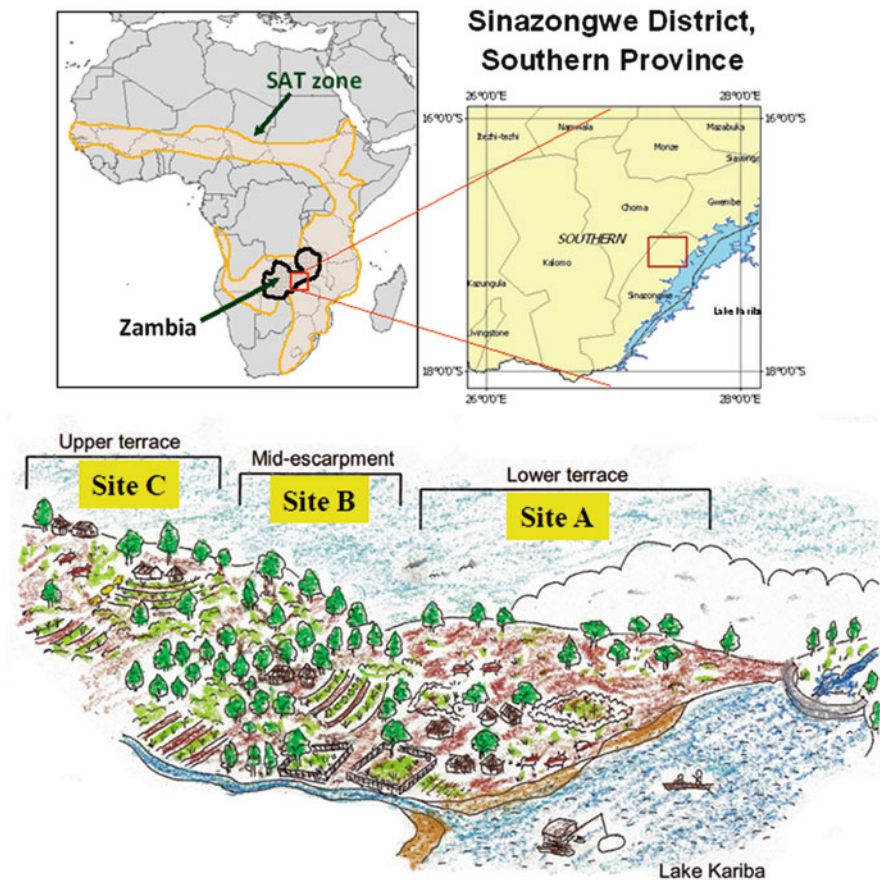


Fig. 9.2 Study sites in Sinazongwe District, Southern Province, Zambia (SAT: Semi-Arid Tropics)

Enumerators met sample farmers weekly and collected data on: (1) various social economic activities, including agricultural production, income, consumption, and time use; (2) body measurement, body weight, height, skin-fold thickness, and upper-middle arm circumference of household members; and (3) on-farm rainfall using rain gauges.

9.3 Threshold of Human System to Food Security against Climatic Variability

Threshold is defined as a certain level of key variables beyond which the system concerned moves to an alternative steady state and behaves in a different way with different feedbacks (Walker et al. 2006a; Gunderson 2003). The threshold provides

important information about whether the system crossed the critical point and moved to an alternative state, i.e., regime shift. In systems ecology, this concept has been widely accepted and applied (Scheffer et al. 2001). However, when we consider the thresholds of human systems, the actual existence of such thresholds is less clear, because societies always have some feedback system to accept disturbance and avoid collapse, even in the face of catastrophic events such as natural disasters. Thus, we use the term quasi-threshold to mean that crossing the limits does not necessarily move the system to another regime. The following section discusses an environmental shock that occurred at our study sites and its consequences, i.e., quasi-thresholds in the context of food security under variable rainfall.

9.3.1 Rainfall Variability and Its Impacts on Agricultural Production

Environmental variability (e.g., rainfall variability) affects crop yield from a farmer’s field, thus directly affecting food availability and consumption (i.e., survival of household). Historical rainfall data indicate that in Southern Province in Zambia the major droughts over the last 20 years occurred during the 1991/1992, 1994/1995, 2001/2002, and 2004/2005 cropping seasons. The production of maize, the major staple food in Zambia, as well as rural livelihoods has been directly affected by the level of precipitation. For example, the share of poverty in Southern Province increased from 79 % in 1991 to 86 % in 1993 immediately after the severe 1991/1992 drought (CSO 2007).

Figure 9.3 shows the daily mean and accumulated precipitation (mm) at Sites A, B, and C during the three cropping seasons, 2007/2008, 2008/2009, and 2009/2010. Rain usually begins in November and ends in April. We installed 48 rain gauges at our study sites to measure on-farm precipitation. Although our study sites are located in a drought-prone area of Zambia, precipitation during the three cropping seasons was much higher than the district’s annual average (Kanno et al. 2011, 2013). On 29 December 2007, the Sinazongwe District, Southern Province, experienced heavy rainfall. The rain gauges we installed at Site A received 473 mm, on average, especially during the last week of December 2007, whereas the annual average rainfall in Sinazongwe District is 694.9 mm (Saeki et al. 2008). Although the two cropping seasons 2007/2008 and 2009/2010 were wet years, the rainfall patterns were quite different. During the 2007/2008 cropping season, heavy rain occurred in December, whereas during the 2009/2010 cropping season, heavy rain occurred in February. The heavy rain in December 2007 was associated with a La Nina year, and the heavy rain in February 2010 was associated with an El Nino year. Notably, farmers are facing not only seasonal variations but also annual variations in rainfall.

This heavy rainfall damaged the maize fields in the area. Among the three study sites, damage was the most severe at Site A. After the heavy rain, about 30 % of the damaged fields were abandoned, and only 54 % were replanted with maize.

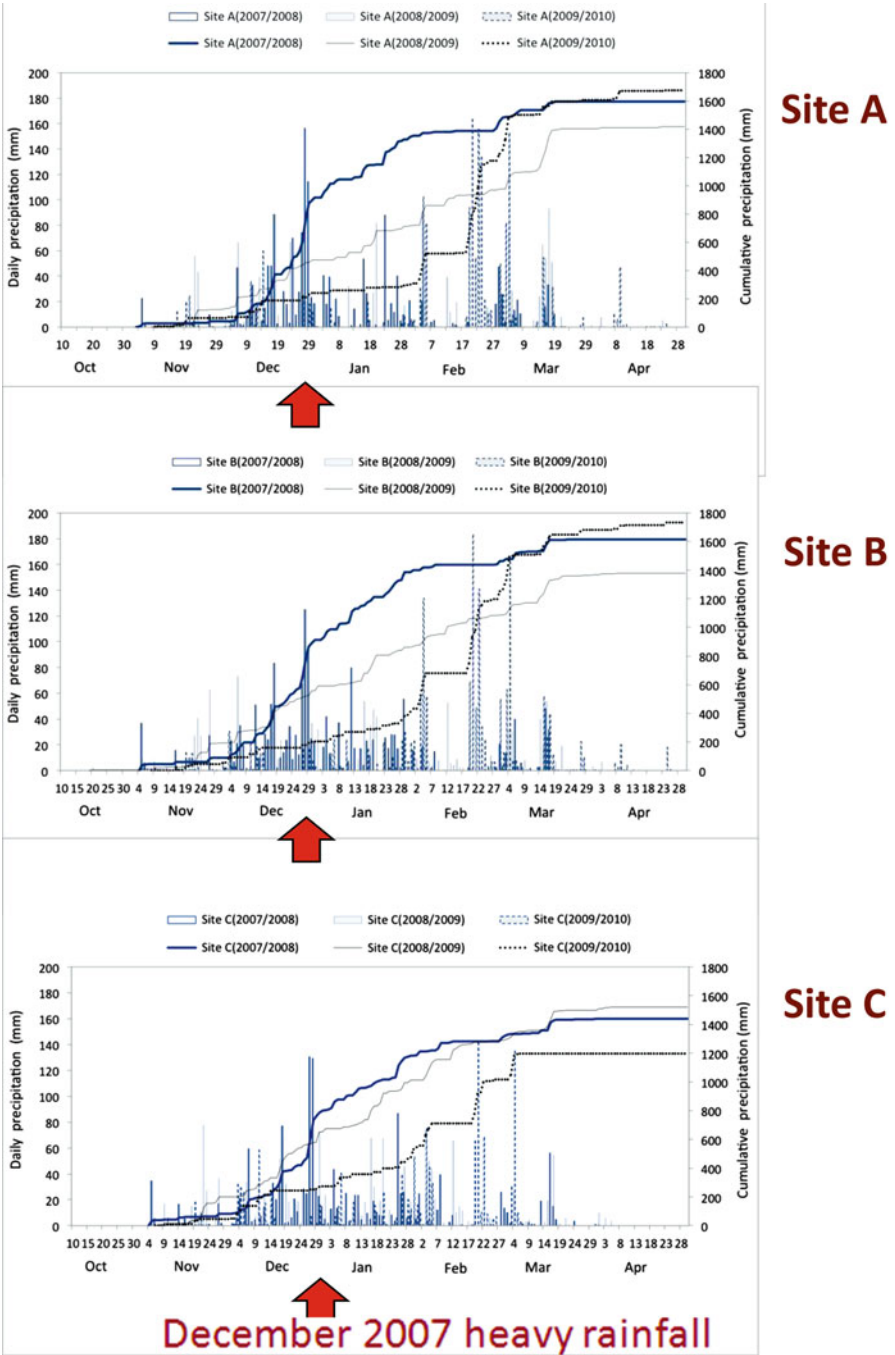


Fig. 9.3 Daily mean and accumulated precipitation (mm) at Sites A, B, and C during the 2007/2008 to 2009/2010 cropping seasons. From Kanno et al. (2011)

At Site C, switching from maize to sweet potato was a common practice. The topographical location of agricultural fields has been shown to mitigate climate variability (Yamashita et al. 2010; Miyazaki 2011a, b). This heavy rainfall resulted in a decline in maize production in 2008 and affected the food consumption, health, and nutritional status of household members.

9.3.2 *Changes in Food Consumption and Quasi-Threshold*

Food security means “the physical and economic access at all times to sufficient, safe and nutritious food to meet the dietary needs and food preferences for an active and healthy life” (IFAD 1996). Food security is closely related to the absolute concept of poverty, which emphasizes the lack of a given level of food. Thus, food insecurity is the situation where people fall below a pre-determined food security threshold (Bellu and Liberati 2005).

The Zambia Central Statistical Office (CSO) defines absolute poverty based on a minimum calorie intake, 2,094 kcal per adult per day (14,658 kcal/week), following the World Health Organization’s recommendation. The World Bank uses a lower minimum food requirement standard, 1,334 cal per adult per day (12,418 kcal/week) (World Bank 2007). In monetary terms estimated from the minimum food basket, the extremely poor group is defined by an income level below 65,710 Zambian Kwacha (ZMK) per adult per month in 2006. This income level considers only food expenditure and, thus, indicates the level of food insecurity. The moderately poor group is defined by an income level above 65,710 ZMK but less than 93,872 ZMK per adult equivalent per month in 2006. This income level includes food and non-food expenditures. An income level above 93,872 ZMK per adult per month is considered non-poor.

Figure 9.4 shows the changes in average food consumption level per week per adult equivalent at Site A from November 2007 to December 2009. The red lines indicate the quasi-threshold of food security, in this case a minimum calorie intake of 14,658 kcal per adult per week and 12,418 kcal per adult per week. This is the quasi-threshold because it is a pre-determined food security threshold and crossing it does not necessarily cause catastrophic events or regime shifts. Our survey revealed the dynamic changes in household food consumption levels with various environmental and socio-economic changes. After the heavy rain in December 2007, calorie intake decreased from 12,000 to 4,000 kcal/week. The level of food consumption did not recover even after the following harvest season. Because of the heavy rain, about 34 % of the maize fields at Site A were damaged (20 % at all three sites) and maize production was reduced (Miyazaki 2011a, b). Reduced production caused an extended lean period, longer than in normal years. In this region, the maize stock does not usually last until the next harvest season, and maize stock of relatively poor households starts to deplete as early as October, which is the beginning of the next planting season. A similar nutritional study in Burkina Faso also confirmed that the calorie intake of household members was

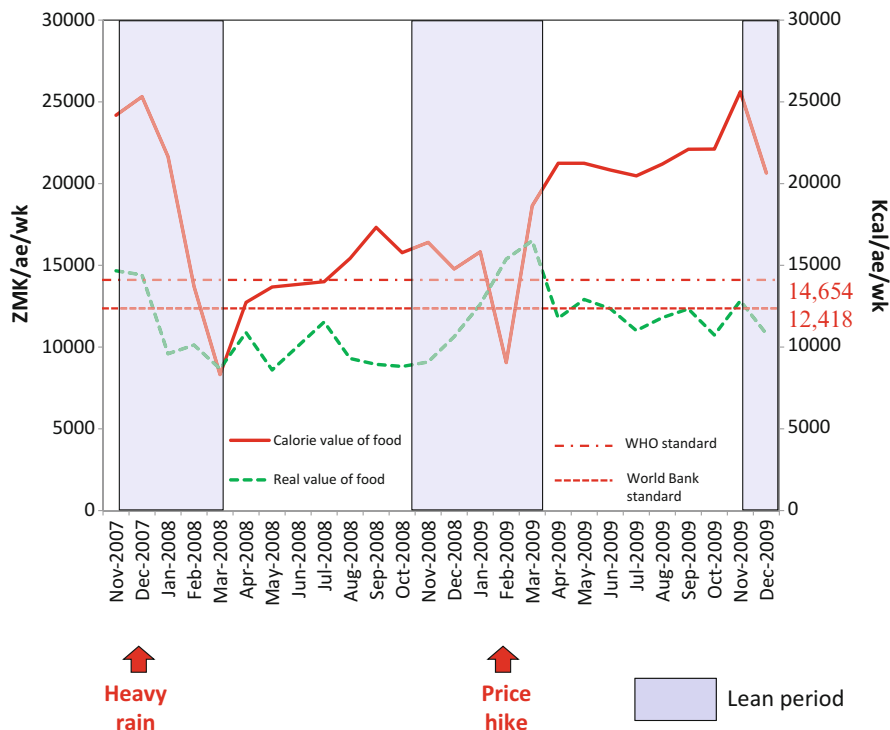


Fig. 9.4 Average food consumption per adult equivalent (ae) per week at Site A. From Sakurai et al. 2011a, b

significantly reduced from 3,000 kcal/day to about 1,500 kcal/day during the food shortage months (Ishimoto 2010).

During the 2008/2009 cropping season, the maize price increased not only locally but also nationally. The retail maize price in Choma, the nearest industrial city where maize meal is produced, soared from 1,140 ZMK in January 2008 to 1,920 ZMK in January 2009, a 68 % price increase. This price hike and local maize shortage due to heavy rain during the previous cropping season in 2007/2008 also affected the local maize market significantly and increased the price further. The price hike had a particular implication for poor farmers, whose harvests were already depleted and who had to secure cash to purchase food.

9.3.3 Changes in BMI Over Time and Quasi-Threshold

Household welfare is affected not only by the quantity of food household members consume but also by the food quality, food diversity, and how the food is prepared. The quantity of food consumed as an input variable into the production of

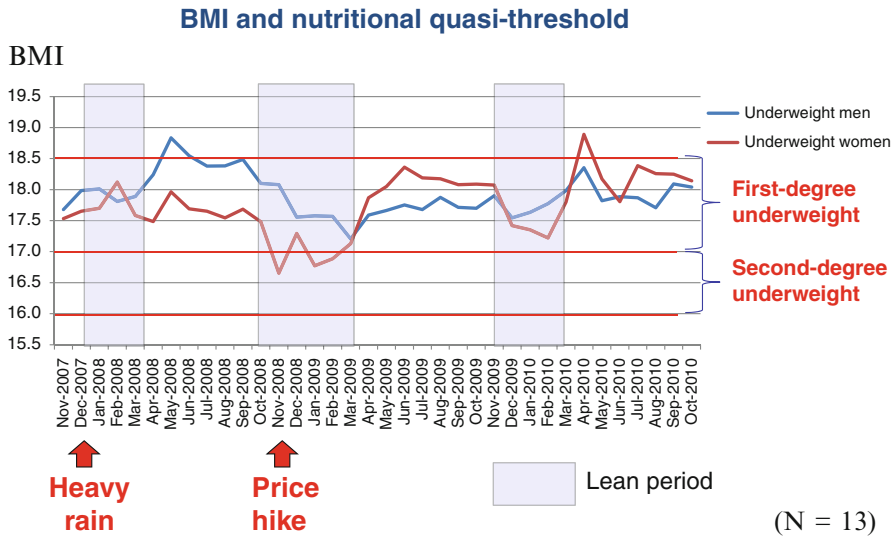


Fig. 9.5 Body mass index (BMI) and nutritional quasi-threshold of BMI-based first- and second-degree underweight men and women. From BMI index provided by H. Kubo

household welfare is a reasonable indicator of household welfare in the absence of other more detailed data. Nutritional status has a closer link to all four dimensions of food security, i.e., availability, accessibility, utilization, and stability, and can be considered as an important indicator of food security. While nutritional status is a better surrogate of food security status than food consumption level because of its ability to capture a more complete aspect of food security, the nutritional status variable has a disadvantage compared to the food quantity variable in that it is less sensitive to immediate changes in household welfare.

For this purpose, a body mass index [BMI = body weight (kg)/height (m²)] of 18.5 was used as another quasi-threshold, in addition to calorie intake. BMIs were calculated using height and weekly measured body weight data for each household member (Yamauchi et al. 2011). A BMI below 18.5 is categorized as first-degree underweight, and a BMI below 16.0 is categorized as second-degree underweight. Yamauchi et al. (2011) found that most adult household members have a good nutritional status, with BMIs in the normal range (between 18.5 and 25). A small fraction of the sampled population was classified as underweight by the BMI standard.

Figure 9.5 shows BMIs and the nutritional quasi-threshold for the underweight group. This figure, in addition to the food consumption level in Fig. 9.4, shows dynamic changes in the nutritional status of village households in terms of BMI and highlights the impact of climate shock on the health and nutritional status of the vulnerable. Figure 9.4 clearly indicates that the nutritional status of household members is seldom above the quasi-threshold level of BMI 18.5 and fluctuates throughout the year depending on various external factors and internal mechanisms

which adjust and stabilize body weight. At Site A, after the heavy rain in December 2007, some farmers replanted maize, which increased the time allocation for agricultural labor and resulted in declines in body weight. Further, due to the price hike mentioned above, food consumption and calorie intake decreased during the lean period and BMI declined sharply.

Changes in the livelihoods of farmers and the underlying reasons, both environmental and socio-economic, must be recognized to understand the overall context. From a resilience perspective, it is important to consider how household members recover from shock. After the heavy rain in December 2007, 20 % of maize fields were damaged at all three sites. Among all study sites, Site A received most severe damage (34 % of maize fields were damaged). Some farmers replanted maize, some switched to sweet potato cultivation, and some engaged in selling livestock to secure cash income. Our analysis shows that when total income decreases, staple food consumption (mainly maize) decreases, but vegetable consumption decreases to a lesser extent (Kitsuki and Sakurai 2011). This is because cash is needed for households to purchase maize but is not needed to collect wild fruits and vegetables, which indicates the importance of cash income during food shortage periods for staple food consumption.

Farmers living near the poverty line often temporarily cross this food poverty and nutritional quasi-threshold. For the transitional food poverty, we must understand the causes and mechanisms of this dynamic change and develop countermeasures which enhance household capacity to adapt and cope to mitigate food insecurity and its impact for faster recovery.

9.4 Assessing General Resilience at a Higher Scale

Social–ecological systems are linked across spatial and temporal scales. Resilience of an existing scale depends on what happens at a scale above and below it (Walker et al. 2006a). Households, local communities, and regional and global markets intricately influence, and are influenced by, each other. Although it is beyond the scope of this chapter to test this cross-scale dynamic relationship empirically, decisions made at one level will influence the others and vice versa. Downward resilience at a macro level and upward resilience at a micro level can enhance or erode resilience at the scale under study. For each study site, household is the lower scale; the district and higher level is the site's higher scale. Upward resilience at the household level was examined with respect to the heavy rainfall shock. Our attention will now shift to downward resilience at a macro level.

The resilience assessment in previous sections involved identifying threshold effects after flood and heavy rain perturbations. This type of specified resilience assessment is necessary because the threat has known threshold effects. Farmers can fall into a poverty trap if the climate shock is pervasive and prolonged. Focusing on climate risks alone is not sufficient, because farm households face

other risks besides climate. Excessive attention to develop specified resilience may result in an unintended loss of general resilience to other new shocks. Here, we approach general resilience to food insecurity by assessing the general capacity of households to absorb shocks, self-reorganize, learn and innovate in combination of assessing four dimensions of food security.

Resilience to food insecurity is a multi-faceted concept and is not readily observable. Direct assessment of resilience for monitoring and management in a non-quasi-experimental setting is challenging. Researchers at the Food and Agriculture Organization of the United Nations (FAO) innovatively proposed an indirect method to assess resilience by modeling resilience to food insecurity as a composite of latent variables (Alinovi et al. 2010a, b). A multi-stage latent variable model is used to estimate resilience scores based on a two-stage factor analysis estimation. The proposed resilience assessment method provides not only a quantification of resilience for resilience monitoring but also an identification of causes of being less resilient for resilience management. The resilience estimation method involves resilience component identification, resilience component function specification and estimation, and resilience score estimation as a weighted sum of its components.

Here, we assert that resilience to food insecurity (R) is a function of the following factors (Alinovi et al. 2010a):

$$R = f(\text{Income}, \text{Asset}, \text{SafetyNet}, \text{BasicServices}, \text{AgroTechno}, \text{AdaptiveCapacity}, \text{Stability}) \quad (9.1)$$

where *Income* is having income and access to food at all times; *Asset* is having agricultural and non-agricultural assets such as house, land, and livestock for productive use and for a cushion against shocks; *SafetyNet* is having access to social safety nets such as food aid, food for work, and remittances; *BasicServices* is having access to basic services such as clean drinking water, sanitation, health care, electricity, etc.; *AgroTechno* is having sound agricultural and technological practices such as access to extension and veterinarian services and to agricultural inputs; *AdaptiveCapacity* is having the capacity to adapt to shocks such as education and diversity of income sources; and *Stability* is having stability in all of the above components over time.

The components of resilience to food insecurity are specified based on the four pillars of food security, i.e., food production or availability, food access, food utilization, and stability. Although agricultural and technological practices determine food production, income influences access to food. Access to basic services such as drinking water and health care services can be loosely linked to food utilization. An absence of shocks was an indicator of stability in food supply, food access, and utilization. When shocks were unavoidable, assets, safety nets, and adaptive capacity allowed individuals and households to mitigate the impact of the shocks and smooth food consumption levels.

9.4.1 *Defining Indicator Variables*

The determinants of the resilience components are specified as follows:

Component	Indicator
Income and food access	Per capita income (continuous)
	Per capita consumption (continuous)
Asset	Household perception of food security (scale of 1 to 3)
	Non-agricultural asset values per capita (continuous)
Social safety net	Agricultural asset values per capita (continuous)
Access to basic services	Amount of remittance and transfer received (continuous)
	Access to clean water (dummy)
Agricultural practices and technology	Access to credit (dummy)
	Access to electricity (dummy)
	Access to telephone (dummy)
	Distance to public transportation (continuous)
	Distance to basic school (continuous)
	Distance to health center (continuous)
	Perception of school quality (dummy)
	Use of chemical fertilizers (dummy)
	Use of manure (dummy)
	Use of pesticides (dummy)
Adaptive capacity	Use of veterinarian services (dummy)
	Use of irrigation (dummy)
	Number of household income-generating activities (count)
	Adult household members in employment activities (%)
	Average years of education of adult household members (continuous)
Stability (multiplying each indicator by -1 to change an instability indicator to a stability indicator)	Non-food expenditure (%)
	Basic coping capacity defined as an inverse of the severity-adjusted coping strategy index (coping capacity is set to 1 if the household has not used any coping strategies) (%)
	Self-assessed income stability (categorical)
	Household members that lost job in the last 12 months (dummy)
	Household members that fell ill during the last 2 weeks (%)
	Share of transfer (%)

Data used in this analysis are based on Zambia's 2004 Living Condition Monitoring Survey (LSMS), 2004. The survey is nationally representative and was conducted by the Central Statistical Office (CSO). Sample size was 19,340 households.

9.5 Results of Resilience Indicator Analysis

The resulting resilience scores and scores of its components were normalized with zero mean and unit variance. A profile of resilience to food insecurity was as expected. Female-headed households were more vulnerable than male-headed households (−0.1298947 and 0.0390073, respectively). Resilience to food insecurity varied by household-head age groups in an inverted U shape (see Fig. 9.6) and peaked at a relatively young age (26–35 years). This was not surprising considering that Zambia’s life expectancy at birth in 2009 was 46.3 (World Bank 2011) and age at retirement was 55. Those aged beyond 55 form the most vulnerable group.

The agricultural sector was generally the least resilient group, followed by the construction and manufacturing sectors; these groups are largely comprised of low-skilled labor or the urban poor (Fig. 9.7). Households working in the utilities and financial sectors appeared to be the most food secured. Within the agricultural

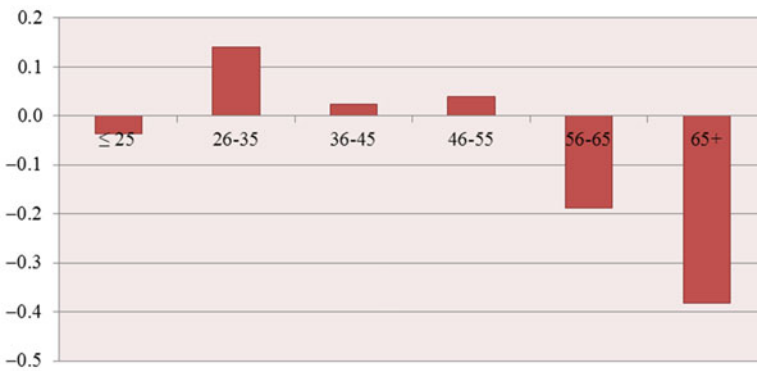


Fig. 9.6 Resilience scores by age group of household head

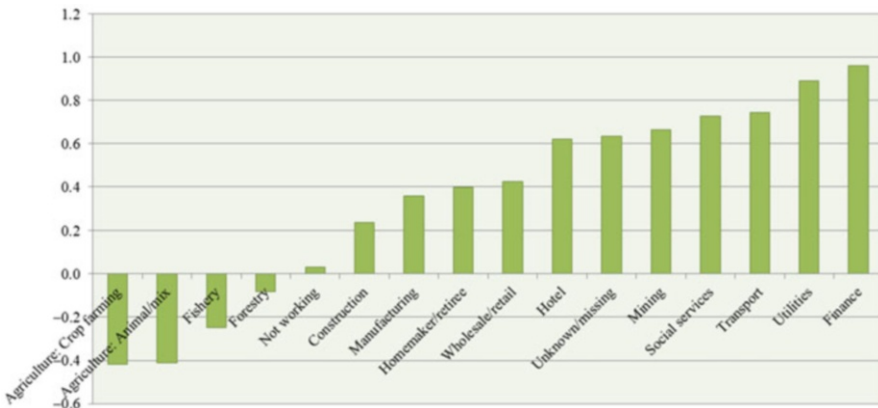


Fig. 9.7 Resilience scores by occupational industry of household head

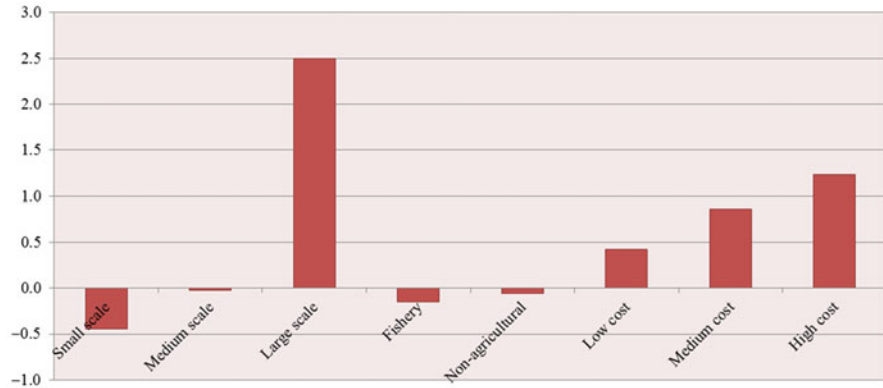


Fig. 9.8 Resilience scores by household stratum



Fig. 9.9 Map of resilience scores by province

sector, large-scale commercial farmers were the most resilient overall, and small-scale farmers were the least resilient overall (Fig. 9.8). Urban households in locations ranging from low- to high-cost residential areas were generally more resilient to food insecurity than their rural counterparts. A map of resilience indicators within the provincial and district boundaries of Zambia is presented in Fig. 9.9 and shows that the relatively more urbanized provinces, such as Lusaka, Copperbelt, and Southern, are more resilient to food insecurity than the less developed provinces. Table 9.2 details the suggested causes of resilience. The

Table 9.2 Resilience scores and components by province

Component	Province								
	Lusaka	Copperbelt	Southern	Central	Northwestern	Luapula	Northern	Eastern	Western
Resilience	0.647	0.414	-0.011	-0.152	-0.219	-0.264	-0.298	-0.303	-0.385
Access to basic services	0.720	0.572	0.001	-0.309	-0.357	-0.171	-0.480	-0.221	-0.480
Adaptive capacity	0.701	0.391	-0.013	-0.094	-0.197	-0.326	-0.269	-0.431	-0.303
Access to food	0.203	0.097	-0.103	-0.018	0.102	-0.099	0.043	-0.092	-0.287
Non-agricultural asset	0.082	0.010	-0.054	-0.012	-0.090	-0.116	-0.101	-0.085	-0.109
Social safety net	0.044	0.009	0.093	-0.098	-0.139	-0.143	-0.091	-0.039	-0.121
Agricultural asset	-0.005	-0.008	-0.007	0.036	-0.008	-0.008	-0.008	-0.008	-0.008
Agro-technological practice	-0.286	-0.264	0.212	0.173	-0.243	-0.261	-0.143	0.822	-0.173

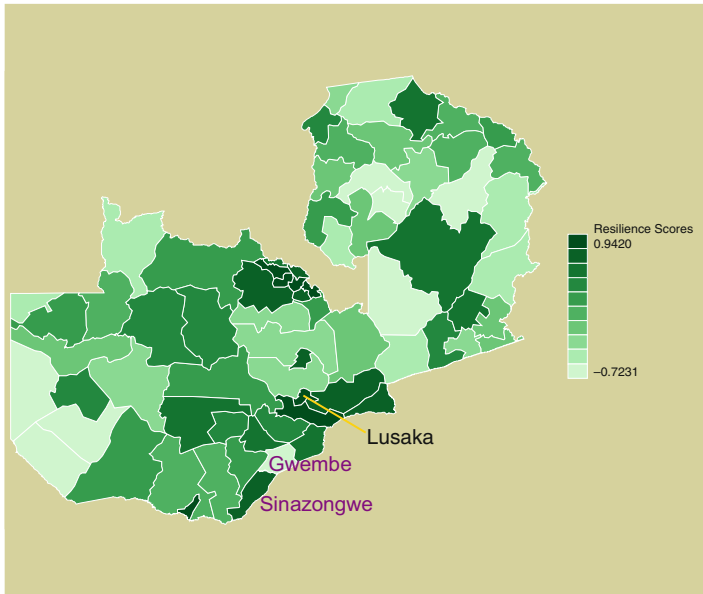


Fig. 9.10 Resilience map at the district level, Zambia, 2004

more resilient provinces tended to have better access to basic services, greater adaptive capacity, greater access to food and income, more non-agricultural assets, and better access to social safety nets. Figure 9.10 shows that the Sinazongwe District in Southern Province, where our study sites were located, is relatively more resilient than all districts except Livingstone, the former capital city, because of better access to basic services and greater adaptive capacity and income-generating potential (table not shown but available upon request). Gwembe, a district with a relatively poor infrastructure, is the least resilient in Southern Province (see Fig. 9.10). Resilience in the provinces and districts is consistent with our findings at the community level, i.e., the majority of the population is in good health and nutritional status despite the rainfall shock.

The resilience framework can also be used to shed light on poverty and consumption vulnerability classification. Here, vulnerability to food insecurity is defined as the probability of the future consumption of households falling below a minimum consumption threshold and is estimated econometrically using Chaudhuri's method (Chaudhuri et al. 2002). A household is categorized as being a member of one of the four possible groups, i.e., the vulnerable poor, the vulnerable non-poor, the non-vulnerable poor, and the non-vulnerable non-poor. In Zambia, 70 % of households were considered vulnerable, and of those, 43 % were currently poor and 27 % were currently not poor. Of the 30 % non-vulnerable households, 11 % were currently poor and the remaining 19 % were non-poor.

Table 9.3 Poverty, vulnerability, and resilience to food insecurity

Component	Mean score			
	Non-poor		Poor	
	Non-vulnerable	Vulnerable	Non-vulnerable	Vulnerable
Vulnerability	0.180	0.847	0.188	0.894
Resilience	0.952	−0.051	0.219	−0.438
Adaptive capacity	1.014	−0.187	0.505	−0.451
Access to basic services	0.925	0.032	0.054	−0.438
Access to food	0.408	0.091	−0.097	−0.211
Social safety net	0.329	0.019	−0.177	−0.196
Non-agricultural asset	0.164	−0.016	−0.118	−0.128
Agricultural asset	−0.006	0.008	−0.008	−0.008
Stability	−0.187	−0.070	−0.026	0.132
Agro-technological practice	−0.222	0.225	−0.221	0.013

What makes the non-poor vulnerable was their poorer access to basic services, lower adaptive capacity, lower income-generating capacity, and lower access to social safety nets compared to the non-vulnerable non-poor. Their higher agricultural asset holdings, higher employment stability, and greater use of agricultural inputs and agricultural technology suggest that the vulnerable non-poor are likely to be rural medium-scale farmers.

Compared to the vulnerable poor, the non-vulnerable poor had greater adaptive capacity, easier access to basic services, and better income-generating potential. Lower employment stability and lower use of agricultural inputs and technology probably indicates that the non-vulnerable poor were the urban poor (Table 9.3).

9.6 Conclusion and Recommendations

In the SAT, people’s livelihoods are vulnerable to environmental variability. The SAT includes Sub-Saharan Africa and South Asia, where the absolute number and proportion of people who are extremely impoverished will remain large for some time to come. People in these regions largely depend on vulnerable rain-fed agriculture, and food security, livelihood resilience, and poverty reduction are critical issues. As *ex-ante* and *ex-post* risk-coping strategies, the capacity of diversified access to resources is one of the important conditions for resilience. Access to resources is facilitated through a transfer and/or substitution of livelihood from agriculture to livestock, agriculture to non-agriculture, market, social organization, and institution, as well as social network. Rural households and communities in Africa are facing risks not only from natural disasters but also from social and economic changes, such as international price hikes of cash crops, political transition, and changes in land tenure systems and agricultural policies.

Empirical evidence shows that the food security of farmers is threatened by temporally and yearly environmental shock. It is commonly found that some poverty groups often cross the quasi-threshold of food security.

The analysis of large samples revealed that small-scale farmers are where the problem of low resilience to food insecurity exists. They are also a host to solutions for poverty reduction and community food security improvement. Building resilience to food insecurity is a complex policy issue because it involves a large and intertwined set of public policies, including education, health, population, migration, infrastructure, institution, agriculture, social insurance, and safety nets. General resilience to food insecurity can be enhanced by building adaptive capacity, increasing access to basic services, providing a stable economic environment and income-generating capacity, and increasing assets. Adaptive capacity can be enhanced by increasing human capital through education, reducing adult mortality to maintain a high percentage of working adults in the population, allowing flexible immigration policies for effective labor supply, and diversifying the economy to provide diversified livelihood opportunities. Government should also focus their resources on providing social and physical infrastructure such as social insurance, social safety nets, health care facilities, electricity, roads, and public transportation to help markets operate more efficiently. The public should also invest in agricultural research and development to improve seed crops by focusing on shortening maturity times even further to reduce exposure to climatic risks. The sustainable provision of extension services through collaborations with the private sector, non-governmental organizations, and farmers is essential to increase productivity in the agricultural sector.

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