Resilience of Rural Households in Semi-Arid Tropics: A Linkage of Social-Ecological Systems

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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)". Although resilience has been defined and analyzed as ecological as well as social-ecological terms, their integration is still under development. Recently, the concept of resilience has been directly applied to regional development and food security issues where people heavily rely their livelihoods on natural resource base (Perrings, 2006; Mäler 2008; UNDP, UNEP, WB, WRI, 2008; ICRISAT, 2010). Also, academic communities consider that resilience is an important component for achieving sustainability (ICSU, 2010).

Within the 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 be resilient to (recover quickly from) environmental shocks. Although the concept of the resilience has been discussed for the last decade, there are few empirical studies that address empirical investigation of resilience for rural livelihood in developing countries.

"Vulnerability and Resilience of Social-Ecological Systems" (Resilience Project) has proposed qualitative and quantitative approaches to empirically analyze resilience of rural households in Zambia (Umetsu, Shinjo, Sakurai, Shimada, Yoshimura, 2010). We argued that in order to operationalize resilience, it is important for us to consider *resilience* in the context of the human security of rural households in SAT region. In the Resilience Project, we consider resilience *to* environmental variability, such as 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 (Commission on Human Security, 2003).

The purpose of this chapter is to address approaches to study resilience we employ in our Resilience Project and summarize research outcomes in reference to a linkage of social-ecological systems.

Approaches to Resilience

The resilience of social-ecological system for subsistence agricultural households in SAT we consider is resilience *to* environmental variability, *of* food supply and consumption, health status, agricultural production and livelihoods since, in case of emergency such as drought and flood, the most important mission is to secure food supply for survival. Environmental variability that we concern is mainly drought, food and disasters that regions and communities are affected equally

(covariate shock).

In Resilience Project, four themes work together while employing various approaches to resilience. For an empirical approach to resilience, we focus on the mechanism and the speed of recovery in food consumption and livelihoods of agricultural households after shocks such as drought and flooding (Figure 1). Theme 1 measures the level of decline of agricultural production through maize yields. Theme 2 observes the speed of recovery in food consumption, body weight and skinfold thickness. Theme 3 considers qualitatively under what conditions livelihoods do or do not decline, how they recover and the differential coping strategies utilized by households. Theme 4 visualizes the spatial pattern of resource use such as land use by agricultural households and land cover changes. This theme also includes spatial heterogeneity and dynamics of resilience and historical investigation (Evans et al. 2010). For a major disaster, the social-ecological system (SES) has possibly shifted to alternative state in transitional stage in case of 2004 Indian Ocean tsunami.

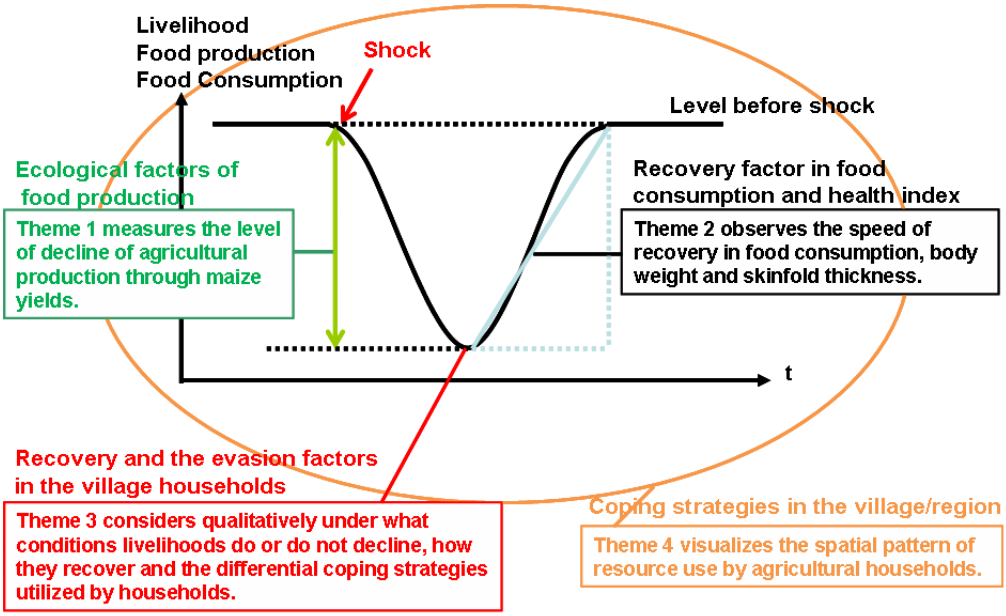

Figure 1. Approaches to Resilience

A Linkage of Social-Ecological Systems and Resilience

Figure 2 indicates our research components, indicators and factors affecting resilience. This figure illustrates the linkage between rainfall, food supply, food consumption, health, and ecosystem services in drought prone area. 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) shown in orange. The connecting arrows show the working hypothesis of the project. Our purpose is to find out the strength and weakness of the connection between these components, test indicators of resilience, and verify factors and conditions for resilience.

Our three field sites are located in Sinazongwe and Choma Districts, Southern Province of Zambia. People in our sample villages are called Valley Tonga. After the construction of Kariba Dam in 1959, Valley Tonga people suffered from huge social and political shocks, i.e., forced relocation from the valley bottom (Colson, 1960; Scudder, 1962, 2010). Site A is close to Kariba Lake and has an

old village before dam construction and a new village relocated after the dam construction. The land is flat. On the other hand Site B is in mid-escarpment with hilly farm lands. Site B residents relocated during the 1990s. Site C is located at the highest altitude at the edge of plateau. Site C

How rainfall variability and other factors are affecting crop production?

Environmental variability (e.g. rainfall variability) affects crop yield from farmer's field, thus directly affecting food availability and consumption i.e., survival of household. The historical rainfall data indicate that in Southern Province in Zambia, the major drought occurred in 1991/1992, 1994/1995, 2001/2002, 2004/2005 cropping seasons. In addition, less rainfall was associated with El Nino years and more rainfall with La Nina years (Yatagai in this issue). The productions of maize, major staple food in Zambia, as well as the rural livelihoods have been directly affected by the level of precipitation. The share of poverty in Southern Province increased from 79 per cent in 1991 up to 86 per cent in 1993 immediately after severe 1991/1992 drought. Although poverty headcounts decreased

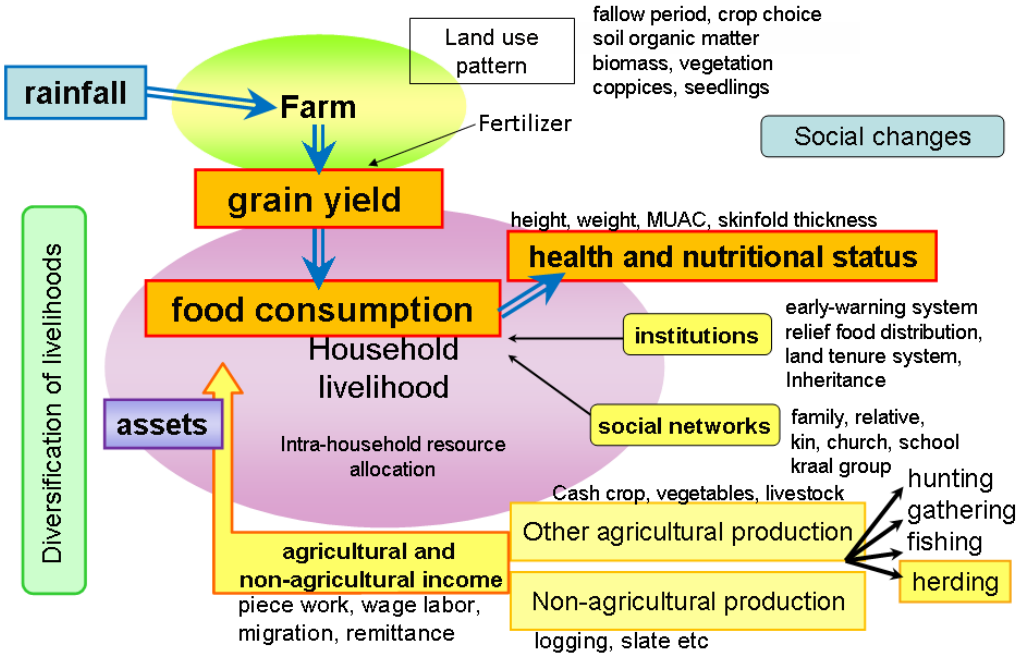

Figure 2. Factors affecting resilience for food consumption levels among households in Zambia (Hypothesis)

until 2002, there is an increasing trend in recent years (Thamana in this issue). Although drought has been a major climatic shock in our study site, the last three cropping seasons 2007/2008, 2008/2009 and 2009/2010 received larger rainfall than the annual average in our study site. The seasonal pattern of rainfall varied among three rainy seasons (Kanno et al., in this issue). Reduced yield by delayed planting indicated that the timing of planting is critical for maize yield (Shimono et al., in this issue). Maize yield is also affected by topography and temperature in Southern Province (Miyazaki et al., 2010); and tree biomass after burning trees in the fields in Eastern Province (Shinjo et al., Miura et al., Sokotela et al., in this issue).

Heavy rain as environmental shock to households production and food consumption

On the 29th of December 2007, heavy rainfall affected the Sinazongwe District, Southern Province. The rain gauges we installed in Site A (among Site A, B and C) received 473 mm this week on average where the annual average rainfall in Sinazongwe District is 694.9mm (Saeki et al., 2008). This heavy rainfall damaged the maize field in the region. In Site A the damage was the most severe among three study sites. After the heavy rain, about 30% of the damaged field was abandoned and 54% of the damaged fields were replanted with maize. In Site C, switching from maize to sweet potato was a common practice. Topographical location of agricultural fields has been shown to mitigate climate variability (Miyazaki; Yamashita; in this issue). This heavy rainfall resulted in decline of maize production in 2008 and affected food consumption, health and nutritional status of household members. Based on the food consumption survey in three study sites, about 80 per cent of energy intake of household members depends on cereals mainly maize (Kon et al., in this issue). Although stunting was prevalent, the nutritional status of sample children was generally good compared to U.S. reference data (Yamauchi et al., in this issue). The long-term weekly interview survey data identified rapid decline and gradual recovery of food consumption after the heavy rainfall. Also body weight declined after food consumption declined. This recovery path became the base for quantitative analysis of resilience. It was revealed that it took almost one year for most households to recover food consumption from the after the rainfall shock and the poor are more sensitive to the rainfall shock in food consumption. The decline of maize yield in 2008 brought food price hike before the next harvest season in February 2009 and affected poor farmers directly (Sakurai et al., in this issue).

Various coping strategies after the heavy rainfall shock to recover food consumption and livelihood

When food supply from their own fields declines, household heads try all measures to secure food supply for the household from other means. In this event, cash in hand played very important role for smoothing consumption levels particularly staple food (Kitsuki and Sakurai in this issue). After the heavy rain, some households started new cash income activities such as vegetable, livestock and poultry sales. From the analysis of cattle holding as an asset, the poor farmers tend to protect cattle and the wealthier farmers tend to protect consumption by selling cattle (Miura et al. in this issue). Nasuda et al., (in this issue) found that households in Site A and B suffering significant crop loss from heavy rain responded not only by cutting consumption by also by increasing working hours among both adults and children. Increasing working hours among children during school semester may have serious implications on children's school attendances and school performances. If agricultural production is not enough to support food supply, then household members pursue non-agricultural activities such as piecework to supply food to the household and maintain livelihoods. For household survival and maintenance of livelihoods, food distribution system of aid agencies and local institutions and organizations that secure access to resources are important (Matsumura in this issue). Also social networks such as relatives and friends play an important role. Recently the use of mobile phone is becoming very popular for requesting monetary support (Ishimoto in this issue).

Even though food production declines in flood years, households employ various coping strategies and alternative economic activities to try to recover from these shocks (Yoshimura et al., in this issue). In addition, regional scale dynamics of resources and livelihoods are the source of resilience to maintain survival and livelihood. Ecosystem services provide a variety of resources to rural communities in the region. For example, agro-ecological systems provide food supply, lake

ecosystems provide fish, forest ecosystems provide emergency food, firewood as energy, water for cooking, and material for construction.

As an ex-ante and ex-post risk coping strategies, the capacity of diversified access to resources is one important condition for resilience (Shimada, 2009; Thamana, 2007). Ishimoto, in this issue, consider resilience with three components, i.e., external shock, assets and capacity. Capacity can be separated into ex-ante adaptive capacity and ex-post coping capacity. The 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 household and communities in Africa are facing not only risks from natural disasters but also risks from social and economic changes, such as international price hike of cash crops, political transition, changes in land tenure systems and agricultural policies. During the course of transition from old systems to new systems, some access channels to resources decreased while other access channels expanded. It is important to consider decline and rise of vulnerability as a bundle in historical context in order to understand resilience (Shimada in this issue).

Indian Ocean Tsunami as covariate shock to the communities

Disaster such as Indian Ocean Tsunami is a covariate shock where communities and region receive a common shock. The Indian Ocean Tsunami that occurred on 26th December 2004 caused severe damage to coastal areas in Indian Ocean. How did Social-Ecological Systems (SES) changed in response to great shock like tsunami? Coastal regions of Nagapattinam District in Tamil Nadu State received the largest damages in India by 2004 Tsunami. After tsunami hit the coastal regions, it took one and a half years for paddy fields to recover from salinity since heavy Monsoon rainfall in 2005 washed salts away from the fields. Human activities to intervene agricultural systems were also important for the recovery (Kume et al., 2009; Kume in this issue). Although the recovery of the farm was rather quick, it took almost three years for social system to recover from the income shock according to our long-term household survey. For the household income to recover to pre-tsunami level, the availability of labor market played a crucial role（Umetsu et al., in this issue）.

Understanding resilience in a comprehensive manner

This paper provides an overview of our results from empirical approaches to resilience. We consider resilience in the context of agricultural livelihood of SAT region. Our target is agricultural households in drought-prone Southern Zambia and their survival and livelihood. We especially consider the recovery of food consumption and food supply as well as livelihood after environmental shock such as drought and flood. What is important is that we need to understand resilience of social-ecological systems in a comprehensive manner in people's daily livelihoods. Resilience is a set of recovery (speed), recovery path (how to recover), recovery mechanism (what drives recovery), and ability including learning process, self-organization and institution that facilitate households and communities to exercise their ability.

Resilience is a concept that has a potential for opening doors to a different approach to natural resource management (Resilience Alliance 2007). The sustainability of rural societies requires an appreciation of the resilience of households and communities. Resilience is the basic capacity that the societies need to acquire to build sustainability at all levels.

References

Colson, Elizabeth. (1960) The Social Organization of the Gwembe Tonga. Manchester: Manchester University Press.

Commission on Human Security. (2003) *Human Security Now*, New York.

Evans, Tom, and Kelly Caylor (2010) Spatial Resilience in Social-Ecological Systems: Household-level Distribution of Risk Exposure and Coping Strategies in Southern Province (Zambia), Vulnerability and Resilience of Social-Ecological Systems, FR3 Project Report.

ICRISAT (2010) Strategic Plan to 2020: Inclusive Market-Oriented Development for Smallholder Farmers in the Tropical Drylands, International Crops Research Institute for the Semi-Arid Tropics, Hyderabad, India.

ICSU (2010) Earth System Science for Global Sustainability: The Grand Challenges, International Council for Science, Paris.

Ishimoto, Y. (2011) Resilience of Rural Farmers and Approaches for Clarifying Capacity: The Level of Household Livelihood, Vulnerability and Resilience of Social-Ecological Systems, FR4 Project Report (in this issue).

Ishimoto, Y. (2011) A Preliminary Report on Support and Requests for Gifts via Mobile Phones: A Case Study of Rural Tonga People in the Southern Province of Zambia, Vulnerability and Resilience of Social-Ecological Systems, FR4 Project Report (in this issue).

Kanno, H., H. Shimono, T. Sakurai, and T. Yamauchi (2011) Analysis of Meteorological Measurements Made over the 2008/2009 Rainy Season in Sinazongwe District, Zambia, Vulnerability and Resilience of Social- Ecological Systems, FR4 Project Report (in this issue).

Kitsuki, A. and T. Sakurai (2011) Seasonal Consumption Smoothing in Rural Zambia, Vulnerability and Resilience of Social-Ecological Systems, FR4 Project Report (in this issue).

Kon, S., T. Lekprichakul, T. Yamauchi (2011) Nutrient Intake, Physical Activity, and Behavioral Patterns of Adults Living in Three Contrasting Ecological Zones in Rural Zambia, Vulnerability and Resilience of Social-Ecological Systems, FR4 Project Report (in this issue).

Kume, T. (2011) Recovery of agricultural livelihoods after the 2004 tsunami in the Andaman Islands, India by interventions by agricultural technologies, Vulnerability and Resilience of Social-Ecological Systems, FR4 Project Report (in this issue).

Kume T., C. Umetsu, K. Palanisami (2009) Impact of the December 2004 tsunami on soil, groundwater and vegetation in the Nagapattinam district, India, *Journal of Environmental Management.* 90 (2009): 3147-3154.

Lekprichakul, Thamana (2011) Zambia's Poverty and Food Security: Measurements, Trends and Decompositions, Vulnerability and Resilience of Social-Ecological Systems, FR4 Project Report (in this issue).

Mäler, Karl-Göran (2008) Sustainable Development and Resilience in Ecosystems, *Environment and Resource Economics*, 39:17-24.

Matsumura, K. (2011) Social Institutions and Resilience for Food Shortage Risk: Food Relief Activities in Southern Province, Zambia, Vulnerability and Resilience of Social-Ecological Systems, FR4 Project Report (in this issue).

Miura, K., H. Kanno and T. Sakurai (2011) Effect of Heavy Rainfall Shock on Asset Dynamics in Rural Zambia-an examination of fluctuations in cattle numbers-, Vulnerability and Resilience of Social-Ecological Systems, FR4 Project Report (in this issue).

Miura R., H. Kuramitsu, S. Takenaka and E. Tembo (2011) A Field Guide to Common Plants of the Petauke District (Partial Presentation), Vulnerability and Resilience of Social-Ecological Systems, FR4 Project Report (in this issue).

Miyazaki, H., M. Miyashita and U. Tanaka, Fluctuation and Controlling Factors of Maize Production under a Variety of Agroecosystems in Southern Province, Zambia, Vulnerability and Resilience of Social-Ecological Systems, FR3 Project Report, pp.166-172.

Miyazaki, H. (2011) Adaptation and Coping Behavior of Farmers during Pre- and Post-Shock Periods, Vulnerability and Resilience of Social-Ecological Systems, FR4 Project Report (in this issue).

Nasuda, A., H. Kanno and T. Sakurai (2011) Analysis of Impacts of Heavy Rainfall Shocks on Time Allocation Changes in Rural Zambia, Vulnerability and Resilience of Social-Ecological Systems, FR4 Project Report (in this issue).

Perrings, Charles (2006) Resilience and sustainable development, *Environment and Development Economics* 11:417-427.

Saeki, Tazu, Hiromitsu Kanno, Hidetoshi Miyazaki, Hitoshi Shinjo (2008), Meteorological Observation in Southern Province, Zambia, Proceedings of the Meteorological Society of Japan 2008 Fall meeting, Sendai, 19-21 November, 2008. p. 473. (in Japanese)

Sakurai, T., A. Nasuda, A. Kitsuki, K. Miura (2011) Vulnerability and Resilience of Household Consumption and Their Determinants-The Case of the Southern Province of Zambia-, Vulnerability and Resilience of Social-Ecological Systems, FR4 Project Report (in this issue).

Scudder, Thayer (2010) *Global Threats, Global Futures: Living with declining living standards (2010). Edward Elgar Publishing, UK.*

Scudder, Thayer (1962) *The Ecology of the Gwembe Tonga*, Manchester: Manchester University Press.

Sesele B. Sokotela, M. Mwale and P. Munen (2010) Preliminary Report: Evaluation of Agro-Forestry Plants for Soil Fertility Restoration and Enhancement of Sustainable Agriculture in the Petauke District, Eastern Zambia (10th May 2010), Vulnerability and Resilience of Social-Ecological Systems, FR4 Project Report (in this issue).

Shimada, S. (2009) Introductory analysis of social vulnerability in rural Africa, *E-Journal GEO*, vol.3(2): 1-16, (in Japanese with English summary)

Shimada S. (2011) Notes on Recent Changes in Vulnerability in a Village in Zambia, Vulnerability and Resilience of Social-Ecological Systems, FR4 Project Report (in this issue).

Shimono, H., H. Miyazaki, H. Shinjo, H. Kanno and T. Sakurai (2011) Effects of planting timing on maize productivity in Zambia, Vulnerability and Resilience of Social-Ecological Systems, FR4 Project Report (in this issue).

Shinjo, H., K. Ando, H. Kuramitsu and R. Miura (2011) Effects of Clearing and Burning on Soil Nutrients and Maize Growth in a Miombo Woodland in Eastern Zambia, Vulnerability and Resilience of Social-Ecological Systems, FR4 Project Report (in this issue).

UNDP, UNEP, WB, WRI (2008), *World Resources 2008: Roots of Resilience-Growing the Wealth of the Poor*. Washington, D.C.: World Resources Institute.

Umetsu, C., H. Shinjo, T. Sakurai, S. Shimada, M. Yoshimura (2010) Resilience of Rural Households in Africa: An Introduction, Vulnerability and Resilience of Social-Ecological Systems, FR3 Project Report, pp.8-15.

Umetsu, C., T. Lekprichakul, K. Palnisami, M. Shanthasheela and T. Kume (2011) Resilience of farming households to the Indian Ocean's Tsunami Disaster in Tamil Nadu of India, Vulnerability and Resilience of Social-Ecological Systems, FR4 Project Report (in this issue).

Walker, Brian, Lance Guderson, Ann Kinzig, Carl Folke, Steve Carpenter, Lisen Schultz. (2006) A Handful of Heuristics and Some Propositions for Understanding Resilience in Social-Ecological Systems. *Ecology and Society* 11(1):13.

Yamauchi T., Kubo H, Kon S, Thamana L, Sakurai T, Kanno H (2011) Growth and Nutritional Status of Tonga Children in Rural Zambia-Longitudinal Growth Monitoring over 26 Months-, Vulnerability and Resilience of Social-Ecological Systems, FR4 Project Report (in this issue).

Yoshimura, M., M. Yamashita, K. Matsumura, H. Miyazaki (2011) Understanding Agricultural Vulnerability, Human Behavior and Relief in Southern Province: Thinking of Rural Farmer's Resilience, Vulnerability and Resilience of Social-Ecological Systems, FR4 Project Report (in this issue).

Yoshimura, M. (2011) Conclusion of Understanding Agricultural Vulnerability, Human Behavior and Relief, Vulnerability and Resilience of Social-Ecological Systems, FR4 Project Report (in this issue).

Zambia Meteorological Department, Monthly rainfall, various years.