RESILIENCE OF SOCIAL-ECOLOGICAL SYSTEMS FOR FOOD SECURITY

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Chieko Umetsu received her Ph.D. in agricultural and resource economics from the University of Hawaii at Manoa. Her research includes work on spatial water allocation models, total factor productivity analysis of the agricultural sector, and, most recently, the resilience of drought-prone agricultural households. Before moving to Nagasaki University, she was leader of the Vulnerability and Resilience of Social-Ecological Systems project at the Research Institute of Humanity and Nature (RIHN).

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)”. 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. Also, academic communities consider that resilience and adaptive capacity of social-ecological system is an important component for achieving sustainability.

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. In other words, resilience of social-ecological system (SES) is considered an important component for achieving sustainability.

“Vulnerability and Resilience of Social-Ecological Systems” (RIHN Resilience Project) has proposed qualitative and quantitative approaches to empirically analyze resilience of rural households in Zambia. We argued that in order to operationalize resilience, it is important for us to consider *resilience* in the context of food security, more broadly human security, of rural households in SAT region. We conducted an integrated study for analyzing farmers’ coping strategy against climatic shocks in Southern Zambia. We collected various intensive household level data including on-farm precipitation, agricultural production, off-farm production, consumption, and anthropometric measures as a proxy for nutritional status for three cropping seasons from 2007 to 2010. The objective of this research is to identify ways in which the resilience to environmental variability of subsistence farmers in the SAT can be strengthened.

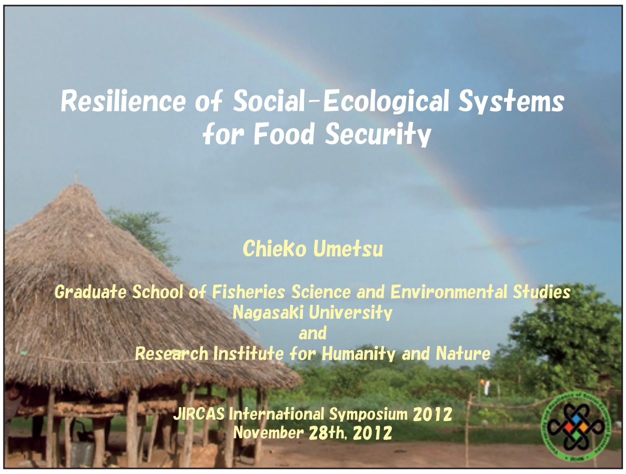
The rainfall pattern varied across rainy seasons and farmers were facing not only annual variation but also seasonal variation of precipitation. The December 2007 heavy rain (473 mm/week) caused significant damages to agricultural production and infrastructure such as roads and bridges in the region. Farmers responded quickly by replanting maize and shifting to other crops. The field experiment suggested that maize yield was strongly influenced by topography and temperature. Thus cultivation under different topographic contexts partly mitigated climatic shocks.

Resilience at the household level was quantitatively measured and factors affecting resilience were identified. A sharp decline in food consumption before harvest was observed after heavy rain in December 2007. After March 2008, food consumption gradually recovered, however the speed of recovery was very slow. Heavy rainfall in 2007 resulted in a sharp increase in maize prices in February 2009 affecting the ability of households to purchase food during the lean period. It took more than one year for most households to recover food consumption to the level before December 2007 heavy rainfall. The recovery speed was high in lowland due to personal gift, public food aid and non-agricultural income. Cattle holdings helped household recovery in upper terrace. Some new activities for getting cash income, such as livestock sales, fishery and wage labor emerged to offset a shortfall of income. Flexibility in employing diverse strategies to successfully cope with climatic shocks is a suggestive of household resilience.

Resilience in SAT context can be defined as the short-run recovery of food consumption, food production and livelihoods. In the long-run, resilience is the adaptive capacity of household, community and region to absorb shocks, adapt to change and to learn, innovate and transform. Rural households and communities in Africa are facing not only risks from natural disasters but also risks from social and economic changes, such as international price hikes of cash crops. Various assets including agricultural

technology, livestock and land holdings and cash income opportunities/abilities are considered as crucial for the recovery of households and communities. Diversified access to resource use help households to recover from shock quickly including information via mobile phone use. The availability and the access to ecological services that supply wild food during the lean period are also important for consumption smoothing.

Strengthening social safety net in different levels is necessary to increase adaptive capacity. Especially female headed households had less resilience compared to male headed households due to poor access to food and agricultural technologies. Development of infrastructure that enable households to access market for crop sales and food purchase, as well as for stabilizing food prices in the region is also important. Comprehensive approaches and long-run observations are necessary to understand complex responses and feed backs due to environmental and socio-economic factors affecting rural households. For enhancing adaptive capacity of individuals and households, long-term strategies are required to improve basic services such as education, medical services, public road and transport. In the long-run, not only is increasing specific resilience against climatic change and/or disaster risks but also increasing general resilience of the society required to prepare for uncertainty. More comprehensive approach to food security is required under the increasing environmental variability.



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RIHN, Kyoto

Vulnerability and Resilience of Social-Ecological Systems (E-04)
Research Institute for Humanity and Nature, FY2007-2011
http://www.chikyu.ac.jp/resilience

Project Leader: Chieko Umetsu
Core Members: Hitoshi Shinjo, Takeshi Sakurai, Shuhei Shimada, Mitsunori Yoshimura, Ueru Tanaka, Hidetoshi Miyazaki, Moses Mwale, Yudai Ishimoto, Megumi Yamashita, Thamana Lekprichakul, Tom Evans, Takashi Kume, K. Palanisami
Members: Kaori Ando, Hajime Kuramitsu, Reiichi Miura, Masako Miyashita, Shozo Shibata, Yoko Noro, Hiromitsu Kanno, Akinori Kitsuki, Sayuri Kon, Harutaka Kubo, Ken Miura, Akiko Nasuda, Hiroyuki Shimono, Taro Yamauchi, Kazuo Hanzawa, Chihiro Ito, Gear M. Kajoba, Shiro Kodamaya, Akie Kyo, Chileshe Mulenga, Tetsuya Nakamura, Noriko Narisawa, Keiichiro Matsumura, Tazu Saeki, V. Geethalakshmi, C.R.Ranganathan, Akiyo Yatagai
Collaborators: Sesele Sokotela, Milimo Chiboola, John Banda

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Outline

- Why do we need resilience?
- Resilience of food security in SAT
- Objectives and approaches
- Linkages of rainfall shock, crop production, food consumption, nutritional status and coping behaviors
- Resilience indicators
- Long-term vulnerability and resilience
- How to enhance resilience

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Why do we need resilience?

- Recently, an increasing frequency of extreme climatic events has been observed. Hence there is a concern that the impacts of global environmental change is increasing.
- However, since it is not certain the environment will change in the future, it is argued that what is important is not to seek ways to adapt to a specific type of shock but rather to enhance ability to respond to unanticipated variability and to learn how to recover from shocks.
- Thus, it is critical to find ways to enhance household and community resilience given future environmental uncertainty.

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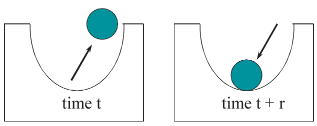
Resilience concept in ecology (#1)

- Engineering Resilience (r)

A return time to a steady-state following a perturbation.



Gunderson (2003)

-Shorter the time t, resilience against disturbance is large.
-Single stationary steady-state

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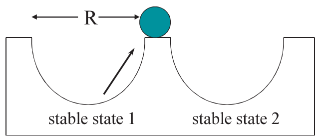
Resilience concept in ecology (#2)

- Ecological Resilience (R)

Magnitude of disturbance that can be absorbed before the system redefines its structure by changing the variables and processes that control behavior.



Gunderson (2003)

-Multiple stationary steady-state
-Multiple dynamic steady-state

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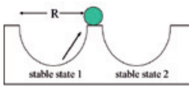
Definition of Resilience



"The capacity of a system to absorb disturbance and re-organise so as to retain essentially the same function, structure and feedbacks – to have the same identity."

(Walker et al., 2006)

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Resilience in the Context of Food Security in Semi-Arid Tropics (SAT)

The ability of people/households, whose livelihoods and agricultural production are highly dependent on natural resource base, to recover their food consumption and production to the original condition against environmental variability such as climatic shock, disaster and socio-economic shocks.

Regions of Semi-Arid Tropics (SAT)

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Objectives of Research

1) to investigate impacts of environmental variability on vulnerability and resilience of human activities such as agricultural production in the Semi-Arid Tropics;

2) to analyse factors determining the ability of households and communities to recover from environmental shocks;

3) to study the roles of institutions and social organizations in improving household resilience; and

4) to identify ways to strengthen the resilience of subsistence farmers and communities in the SAT to future environmental and social shocks.

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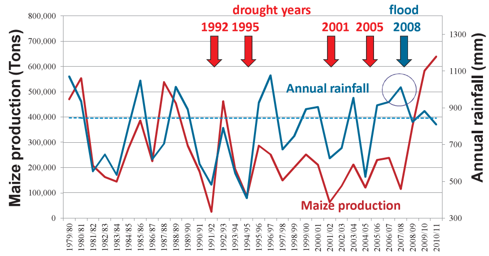
Impact of Rainfall Variability on Maize Production and Poverty in Southern Province, Zambia

- 85% of labor force is in agricultural sector
- Share of poverty headcounts (less than 93,872 ZMK/month in 2006)
  Rural 80% Urban 34% (Zambia 64%)
- Rainfed production system ➡ Rainfall variability affect rural poverty directly



CSO Post Harvest Survey (various years)
Zambia Meteorological Department

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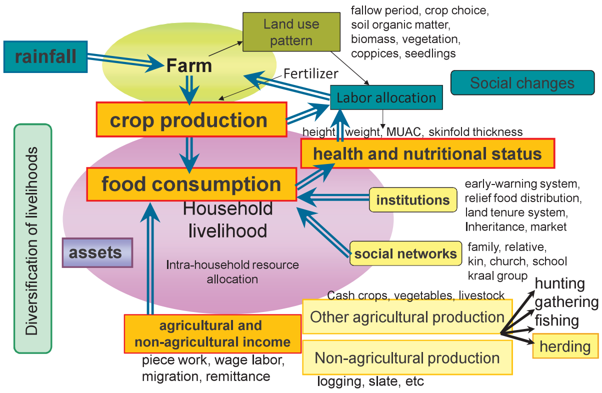
Factors Relating Resilience of Food Security at Agricultural Household Levels (Hypothesis)



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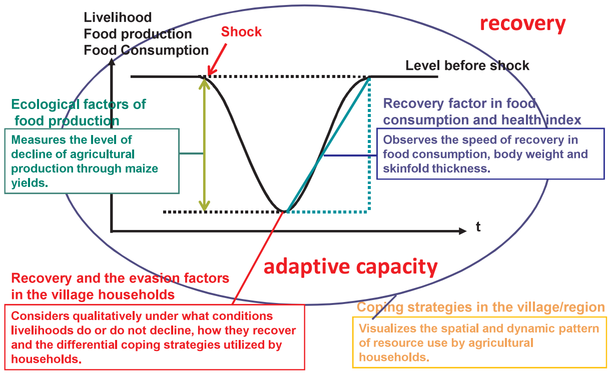
Approaches to Resilience



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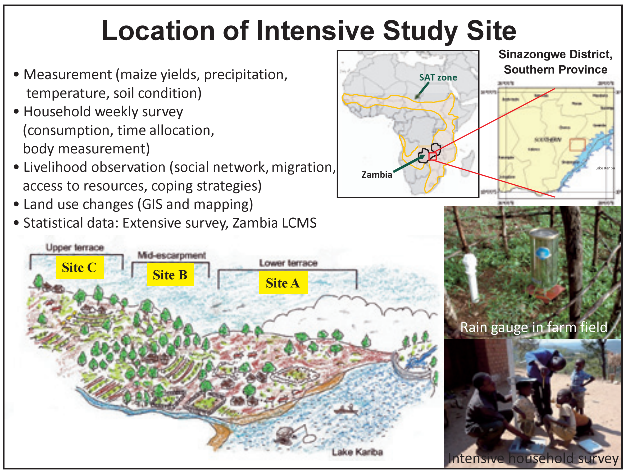

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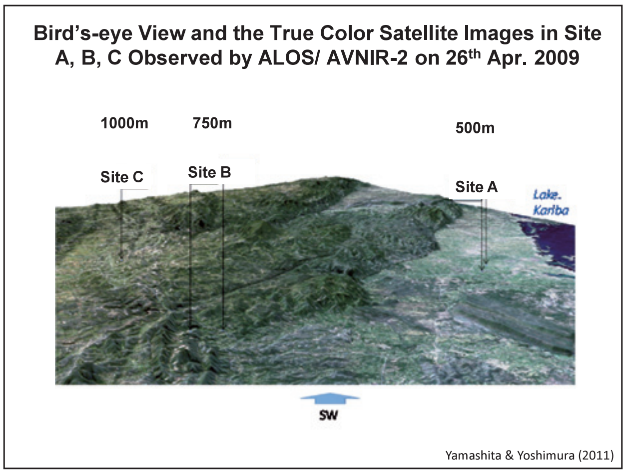

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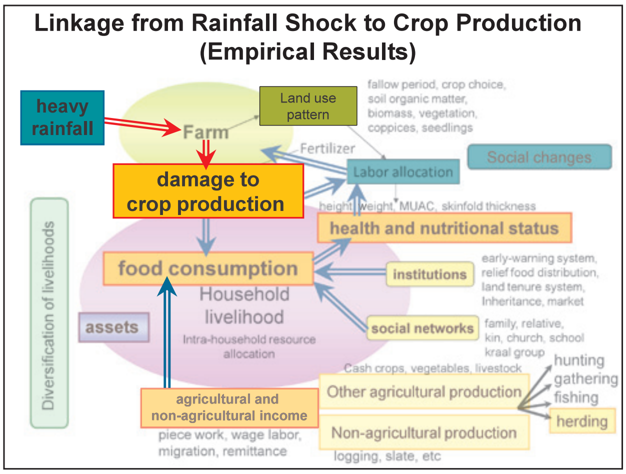

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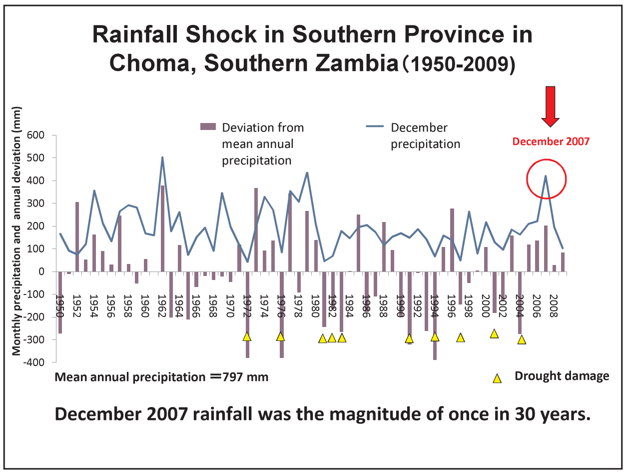

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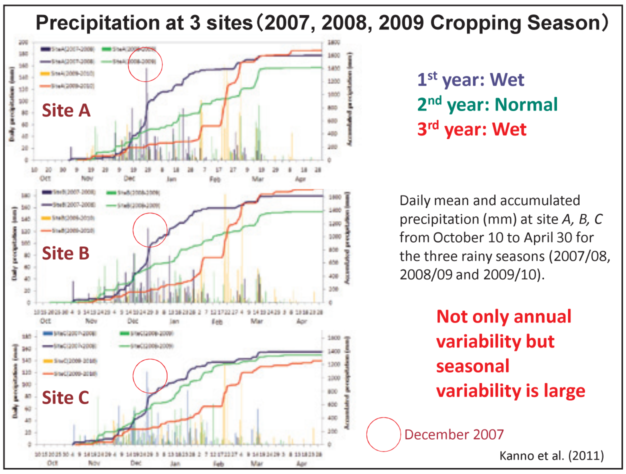

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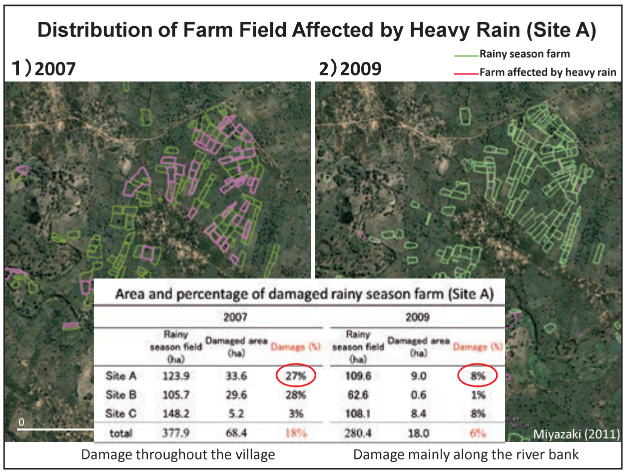

Area and percentage of damaged rainy season farm (Site A)

	2007			2009		
	Rainy season field (ha)	Damaged area (ha)	Damage (%)	Rainy season field (ha)	Damaged area (ha)	Damage (%)
Site A	123.9	33.6	27%	109.6	9.0	8%
Site B	105.7	29.6	28%	62.6	0.6	1%
Site C	148.2	5.2	3%	108.1	8.4	8%
total	377.9	68.4	18%	280.4	18.0	6%

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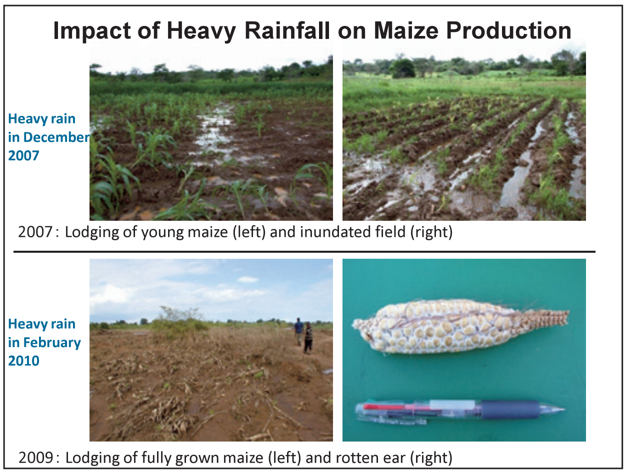

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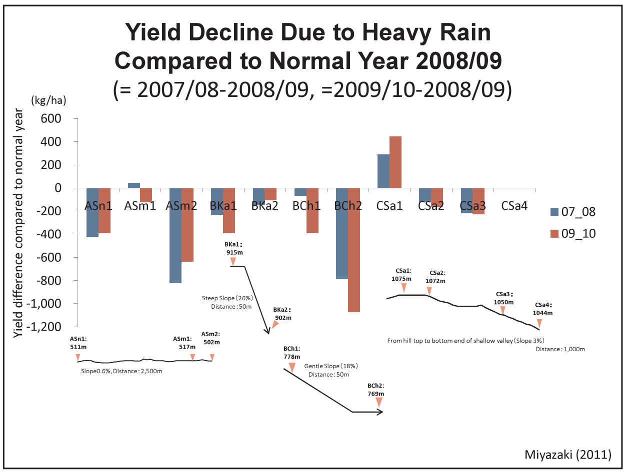

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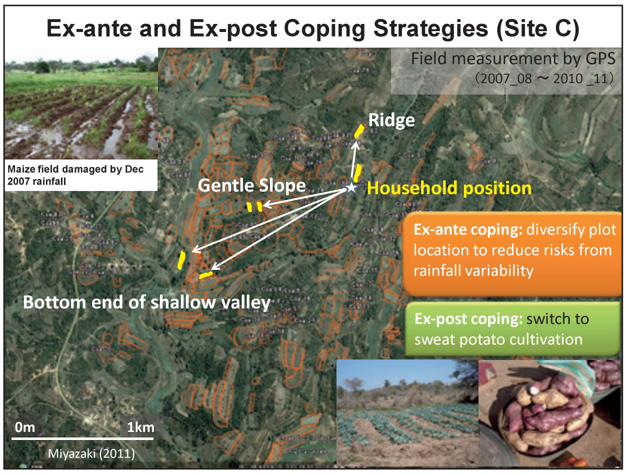

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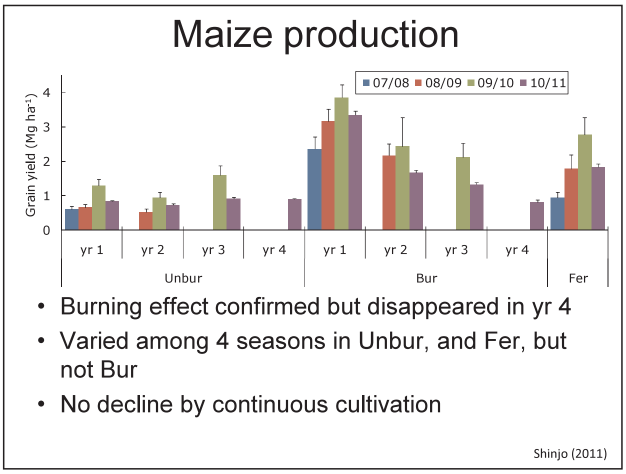

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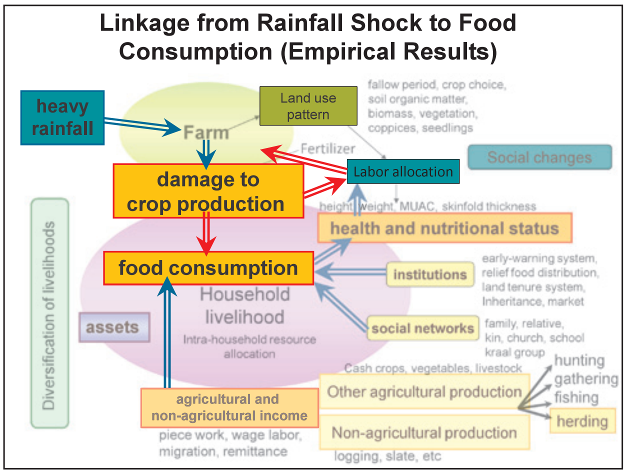

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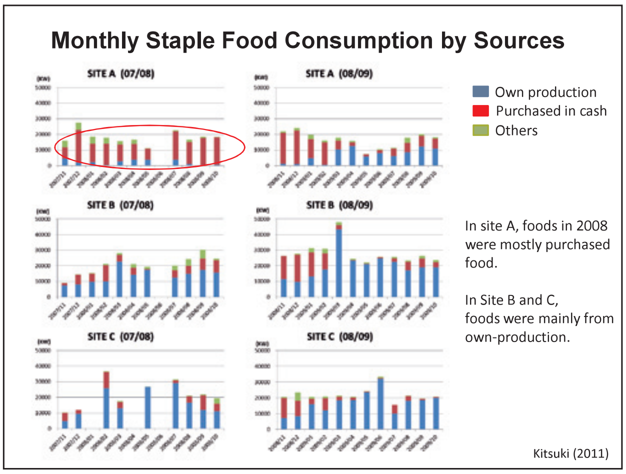

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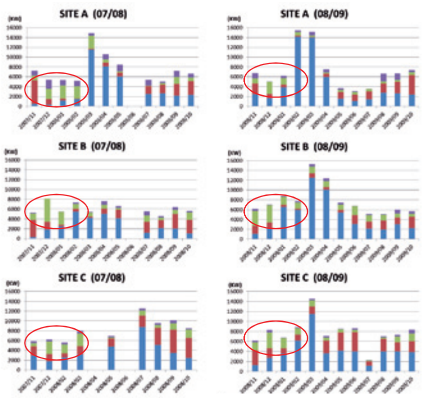
Monthly Vegetable and Fruit Consumption by Sources



During rainy season, wild food collection supplemented vegetable consumption during the lean period.

Kitsuki (2011)

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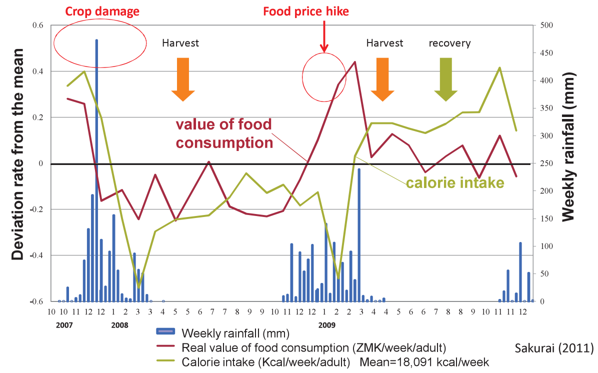
Change of Food Consumption after 2007 Heavy Rain



Impact of heavy rain in Dec 2007 appeared as food price hike in Feb 2009.

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Recovery Speed of Food Consumption (calorie intake) and its Determinants

Sakurai (2011)

Explanatory Variables	Rich Households	Poor Households
Recovery Speed of Food Consumption	0.95++	0.29+
Household Assets		
Total cropped area (ha/Adult)	0	++
Value of cattle (ZMK/Adult)	0	0
Value of other livestock (ZMK/Adult)	+	—
Value of household assets (ZMK/Adult)	0	0
Household Characteristics		
Age of household head	–	++
Age of household head squared	+	––
Years in school of household head	++	0
Adult equivalent household size	0	—
# of observations (# of households x # of months)	8 × 26	7 × 26
R squared	0.36	0.24

-For rich HHs, asset such as livestock and education had positive impact on recovery speed.
-For poor HHs, cropped area was positive but HH size was negatively affecting recovery speed.
-Elder HH head for rich HHs and younger HH head for the poor was increasing recovery speed.

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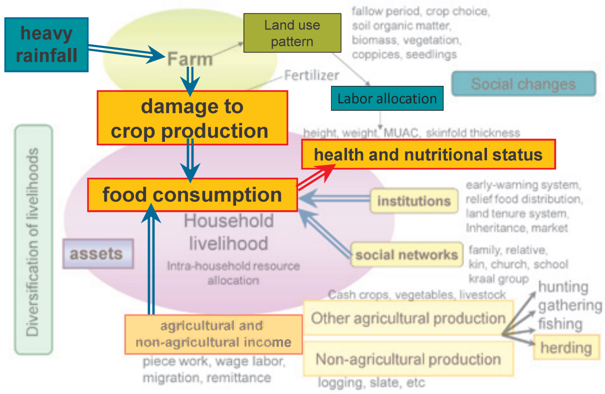
Linkage from Rainfall Shock to Nutritional Status (Empirical Results)



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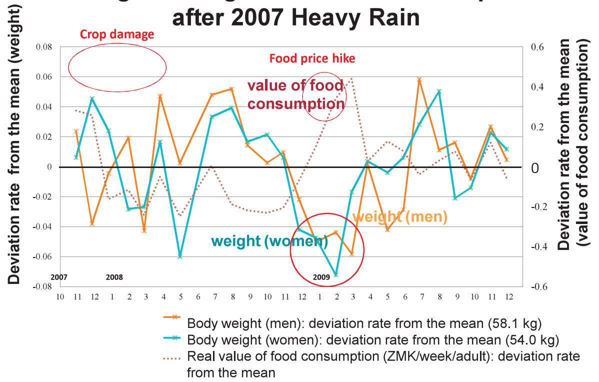
Change of Weight and Food Consumption after 2007 Heavy Rain



Body weight for both men and women declined equally when food price increased.

Yamauchi (2011)

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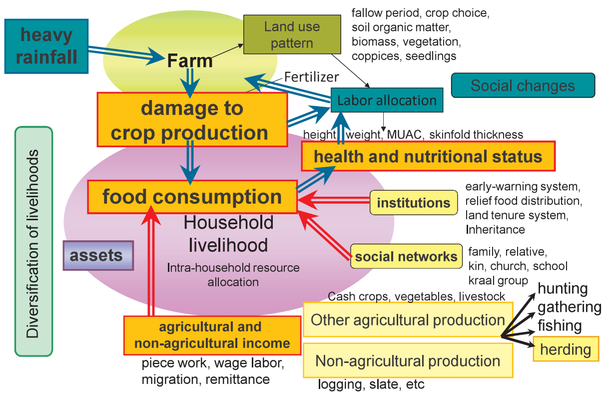
Linkage of Coping Behaviors to Food Consumption (Empirical Results)



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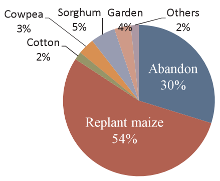
Coping strategies after heavy rain in 2007



On-farm: change in cropping pattern (2008)
54% of the damaged farm was replanted with maize and 30% was abandoned in Site A.

Asset sales and cash income activities (2008)
Households (N=8) that could not sell maize due to crop damage after heavy rain switched to alternative income generating activities such as livestock sales.

2008	Maize sale	Vegetable sale	Livestock sale	Collected food sale	carpentry	Seasonal labor	Others
Asn 6			5.0				
Asn 8		20.0					
Asn 14		40.0					
Asn 29			40.0				40.0
Asn 33			100.0				
Asn 12		30.0	50.0			20.0	
Asn 36		100.0					
Asn 40			70.0				30.0

new
increase
decrease

Miyazaki (2011)

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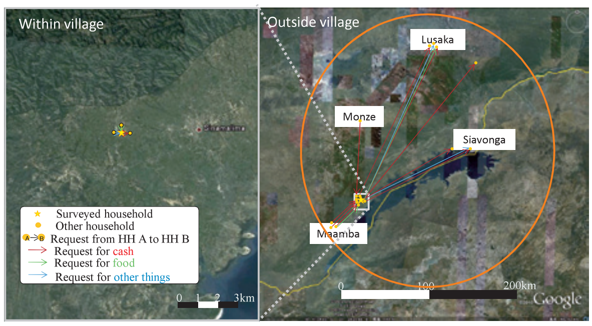
Coping Behavior Using Social Networks: Increasing Mobile Phone Use



Via mobile phone use, emergency requests for food, medical expenditure, school fee to relatives living in distant cities became less costly.

Ishimoto (2011)

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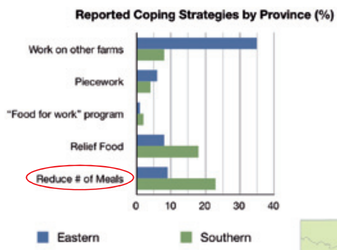
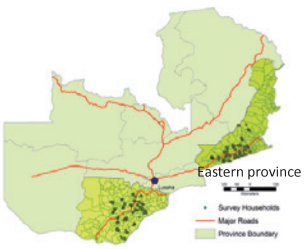
Large-Scale Spatial Analysis



Data: RIHN Extensive Household Survey (2007)
N=1000

The dominant strategy for drought in Southern Province was to reduce number of meals per day.



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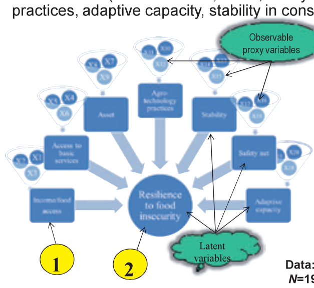
Resilience Indicators for Regional Comparison

We adopted FAO's proposed methodology of a latent variable model (Alinovi et al, 2008) to assess resilience to food insecurity in Zambia.

Resilience to food insecurity is specified as a weighted sum of the following latent variables:

Resilience = *f* (access to food, asset, safety net, access to basic services, agro-tech practices, adaptive capacity, stability in consumption)



Two-Stage Factor Analysis Methodology
- The above RHS variables are not directly observable (latent variables).
-In the first step, we identify some observable proxy variables to measure the latent resilience determinants using factor analysis.
-In the second step, we use the obtained latent variables to quantify resilience scores using another factor analysis.

Data: Zambia Living Condition Monitoring Survey 2004, *N*=19,340 HH

Note: All scores are standardized with 0 mean and variance of 1.

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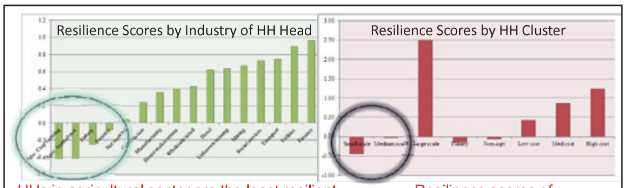
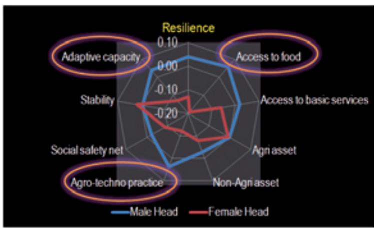


HHs in agricultural sector are the least resilient

Resilience scores of small scale farmers are the lowest



Female headed HHs are less resilient due to poorer access to food, lower adaptive capacity, and agro-technological practices

Note: All scores are standardized with 0 mean and variance of 1.

Resilience Score and Its Components by Gender of Household Head

Lekprichakul and Umetsu (2011)

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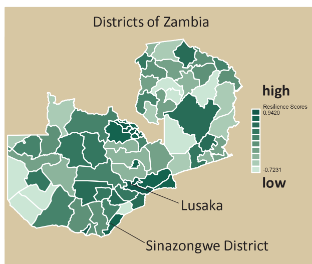
Resilience Mapping

Data: Zambia Living Condition Monitoring Survey 2004, N=19,340 HH



Spatial distribution of resilience scores helps to identify hot spots of relatively low resilience regions.

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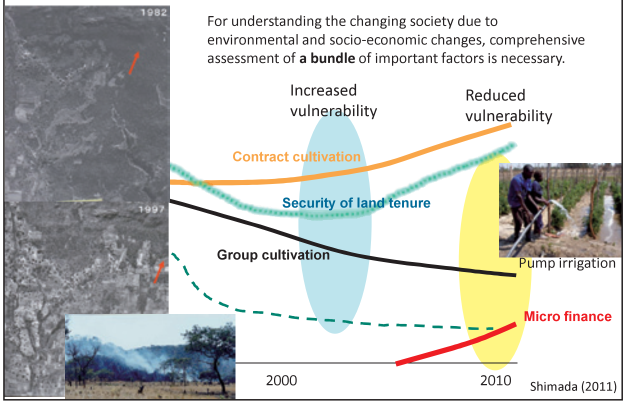
Long-Term Vulnerability and Resilience as an Interaction of Complex Factors

For understanding the changing society due to environmental and socio-economic changes, comprehensive assessment of **a bundle** of important factors is necessary.



Shimada (2011)

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Summary and Policy Implications for Enhancing Resilience to Food Insecurity

- Resilience in SAT context can be defined as the short-run recovery of food consumption, food production and livelihoods. In the long-run, resilience can be defined as the adaptive capacity of a household, community and region to absorb shocks, adapt to changing conditions and to learn, innovate and transform.
- Various assets including technology, livestock and land holdings and cash income opportunities are crucial for recovery of households and communities.
- Access to diverse resources helps households to recover from shocks more quickly. For example, the availability and the access to ecosystem services that supply wild food during the lean period.
- Strengthening the social safety net in different levels is necessary to increase adaptive capacity.
- Development of infrastructure that enables households to access markets, as well as for stabilizing food prices in the region is important.

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Factors Affecting Resilience of Food Security

	household	community	region
Recovery & Adaptive capacity (short run)	*Site A-B-C* -asset holdings -field diversification and agri. practices -crop diversification -cash income -coping capacities	*Eastern/Southern/ Central Province/ India* -market integration -use of local varieties -access to basic services	-access to food/income
Adaptive capacity (long run)	*Site A-B-C* -coping capacities -human capital -ability for skilled work -social network	*Eastern/Southern/ Central Province/ India* -secure tenure system -access to credit -contract farming	*Provincial level* -adaptive capacity -access to job -access to basic services (social & physical infrastructure) -diversified income sources

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For Enhancing Resilience

- Social systems and ecological systems sometimes change or transform at a different rates. Comprehensive approaches and long-run observations are necessary to understand complex responses and feedback due to environmental and socio-economic factors affecting rural households.
- For enhancing adaptive capacity of individuals and households, long-term strategies are required to improve basic services such as education, medical services, public roads and transport.
- To prepare for uncertainty, not only increasing specific resilience against climatic change and/or disaster risks but also increasing general resilience of the society is required in the long-run.

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Last message

- Food security is more than food production.
- More comprehensive approach to food security is required including production, consumption, market with health/nutritional status.

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We acknowledge the financial support by the Research Institute for Humanity and Nature, Kyoto Japan.

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Chairman Mr. Osamu Koyama: Our second keynote speaker is Prof. Chieko Umetsu. Currently she is a professor at the Graduate School of Fisheries Science and Environmental Studies of Nagasaki University. If you see the back of the program, all of the career profiles are specified. Please refer to this for detail. She studied agriculture and resource economics at the University of Hawaii and she studies a wide range of agricultural resource and productivity-related researches. But recently she led a very unique project directly targeting the issue of resilience and vulnerability of social-ecological systems. Today, she will kindly show us a theoretical interpretation of resilience, as well as the results driven by the project she led at the Research Institute for Humanity and Nature in Kyoto. The title of her presentation is “Resilience of Social-Ecological Systems for Food Security.” The floor is yours; please start.

Prof. Chieko Umetsu: Thank you very much Mr. Koyama for a very nice introduction. Ladies and gentlemen, good afternoon. Thank you very much to the conference organizers for inviting me for this very exciting symposium.

I moved to Nagasaki University from October, and before that I was research staff at the Research Institute for Humanity and Nature for about 10 years. For the last several years I have been working with colleagues for a project called “Vulnerability and Resilience of Social-Ecological Systems.” This project involved more than 40 people, including many graduate students, and I would like to acknowledge all of them for their participation in the project. I am quite happy to see Prof. Sakurai and Dr. Saeki here in this room today.

The outline of my talk today is as follows. I first want to explain why we need resilience; then, the implications of resilience of food security, especially in semi-arid tropics (SAT); objectives and approaches of resilience project; linkages of rainfall shock, crop production, food consumption, nutritional status and coping behaviors. I will show the resilience indicators we constructed in the project, and also the implications of long-term vulnerability and resilience. Lastly, how to enhance resilience.

My talk today is basically the result of the resilience project. Why do we need resilience in the first place? Recently, an increasing frequency of extreme climatic events has been observed. So there is a concern that the impacts of global environmental change is increasing. However, since it is not certain that the environment will change in the future, it is argued that what is important is not to seek ways to adapt to a specific type of shock but rather to enhance ability to respond to unanticipated variability and to learn how to recover from shocks. Thus, it is critical to find ways to enhance household and community resilience given future environmental uncertainty.

I would like to explain what resilience is about. The initial concept of resilience started from the ecologists. Of course, there are many people, not only ecologists, who use the similar concept. The initial concept of resilience is called “engineering resilience,” which is the return time to a steady state following a perturbation. The ball in the bowl at the bottom is in a stable state, and once it gets perturbed or shocked, the ball will jump up. It will come back to the original equilibrium condition. So the initial definition of engineering resilience means the return time to the original state. For this initial engineering resilience, for a shorter time t the resilience against disturbance is large. A shorter time of recovery is better. It also shows the only single stationary steady state.

A later resilience concept is called the “ecological resilience,” which is not the return time but the magnitude of disturbance that can be absorbed before the system redefines its structure by changing the variables and processes that control behavior. The later definition of resilience is concerned more with the capacity or the shape of the bowl that carries this green ball. At the same time, they consider the steady state is not unique; there may be one, two or three steady states, i.e. multiple stationary states exist. One steady state may jump into the next steady state. There is no discussion about whether this second steady is better or worse.

Brian Walker and other colleagues of the Resilience Alliance did a lot of the work on the concept and development of resilience. It is defined as “The capacity of a system to absorb disturbance and re-organize so as to retain essentially the same function, structure and feedbacks—to have the same identity of the system."

What does this mean in the real world? That is how we started the resilience project. We consider resilience in the context of food security in SAT. It is most important to consider what resilience you are talking about, against what disturbance you are talking about, and for what purpose you are talking about resilience. We defined resilience as follows in the context of food security in SAT: The ability of people/households, whose livelihoods and agricultural production are highly dependent on natural resource base, to recover their food consumption and production to the original condition against environmental variability such as climatic shock, disaster and socio-economic shocks. So we defined the resilience in this context.

Objectives of our research project were as follows: first, to investigate impacts of environmental variability on vulnerability and resilience of human activities such as agricultural production in the SAT; second, to analyze factors determining the ability of households and communities to recover from environmental shocks; third, to study the roles of institutions and social organizations in improving household resilience; fourth, to identify ways to strengthen the resilience of subsistence farmers and communities in the SAT to future environmental and social shocks.

This graph shows the impact of rainfall variability on maize production and poverty in Southern Province, Zambia. You can see the rainfall as a blue line goes up and down, greatly fluctuating. The red line shows maize production. So you can see that a decline in precipitation means a decline in maize production. In Zambia, 85% of the labor force is in agricultural sector, and the share of poverty—less than US$20 per month—in the rural areas is 80% and in urban areas is 34%. Because in rural areas farmers depend on rain-fed production systems, rainfall variability directly affects the rural poor. The red arrow shows the major droughts in the past. Recently, as you can see, instead of drought, flood came. We first thought about the drought responses, but drought never came and instead floods came, so we switched our focus from drought to flooding.

This is our hypothesis on factors relating resilience of food security at agriculture household levels. First, rainfall affects farm production and crop production. Crop production affects the food consumption levels of the household. Food consumption affects the health and nutritional status of household members directly. When crops fail, then other activities like other agricultural production or non-agricultural production become very important to support the food consumption level of the household. Institutions and social networks and non-agricultural incomes become very important.

This diagram shows our approaches to resilience. We tried qualitative and quantitative approaches to resilience. One group was looking at ecological factors of food production, and measured the decline of agricultural production through maize yield. The level of food production and consumption declines after the shock and recovers after a certain time. Another group looked at the recovery factor in food consumption and health index. They observed the speed of recovery in food consumption, bodyweight and skin-fold thickness. Not only quantitative approaches but also qualitative approaches were introduced. One group considered qualitatively under what conditions livelihoods do or do not decline, how they recover, and the differential coping strategies utilized by households. Also coping strategies were studied in different locations.

This is our study site. The field site is located in Zambia near Lake Kariba. Kariba Dam was constructed during the 1950s and the people living at the bottom of the valley had to relocate uphill. We conducted various measurements, such as maize yields, precipitation, temperature and soil condition. Also a very intensive household survey was conducted, wherein the enumerators came back to the household weekly to ask about food consumption, time allocation, and make body measurement. Also livelihood observation was done by anthropologists, such as social network, migration, access to resources and coping strategies. Also land use changes—famers change land use every year so they used GIS and mapping. Also statistical government data was utilized for extensive survey and analysis.

This is a rain gauge, a soil moisture tube installed in every farmer's major maize plot. Weekly household survey was done together with anthropometric measurement. The locations of sites A, B and C are three locations from the low fields to the hillside.

This is a birds-eye view, a 3D image created by satellite imaging. You can see Lake Kariba, and site A is at the bottom in a very flat area, while site C is the highest, at the edge of the plateau and site B is very steep.

First I would like to explain how heavy rain impacted crop production. This figure shows long-term precipitation from 1950. The bar chart shows the deviation from mean annual precipitation, which is around 800mm in this area. This yellow triangle shows drought years, and you can see that many drought years occurred in this region. We especially focused on coping strategies against the December 2007 heavy rainfall. The magnitude of this heavy rainfall was about once in 30 years. This heavy rain destroyed all the infrastructure, bridges and roads, and vehicles could not gain access to the households.

This diagram shows the precipitation at three sites, utilizing the rain gauge I showed in previous slides. This shows the three cropping seasons. Cropping season usually starts from October/November until the harvest in March/April. During the rainy season they grow maize and other crops. This blue line shows the first year rainfall, and this is the December 2007 heavy rainfall as a main shock. The bar chart shows the daily precipitation and this line shows the cumulative precipitation. As you can see, there is quite a different pattern for three years. For example in the first year there was this major rainfall in December and then the later month was not so severe rainfall. But in the third year, initially the rain did not come but in February they had heavy rain. So the pattern is quite different year by year. Not only annual variability but also seasonal variability is quite large. This is a situation that farmers are facing: the heavy rain may come in December or it may come in February.

In the December 2007 heavy rainfall, this purple line shows the damaged fields; damage was throughout the village. In the 2009 rainfall the damage was very patchy. Because site A is rather flat, it inundated many fields, and the damage was the highest in site A. December heavy rainfall and February heavy rainfall had different impacts. For example, when they had heavy rain in December, all of the maize failed, but there was still moisture in the soil so they could replant maize. Or after crop failure of maize they can switch to sweet potatoes. But when they had heavy rain in February, this is almost the end of the crop season and replanting maize is not possible because of the soil moisture.

This diagram shows yield decline due to heavy rain compared to normal year 2008/2009. You can see that the blue shows the 2007 cropping season and the red is the 2009 cropping season. Almost all the fields had declined yields due to heavy rain. Only this region, which is a higher place, had increased yield. So this diagram shows that maize production is very weak in heavy rain.

What do farmers do after the heavy rain? Of course they do various coping strategies. For example, one household has a plot on the ridge and a plot on the gentle slope and a plot in the valley. The ex-ante coping strategy means diversified crop locations to reduce risks from rainfall variability. When a field is inundated, farmers can quickly switch to sweet potato. The ex-post coping is to switch to sweet potato cultivation or replant maize. So the diversified production system can partially mitigate these risks.

This diagram shows not in the southern province but in the eastern province, an experimental field site of our project. Here they did an experiment of changing the fallow period. This is the first year and the second year, changing the clearing year, and comparing how the yield might decline depending on the fallow period. "Unbur" means there is no burning before the land preparation. "Bur" means burning was conducted before the land preparation. So you can see that if there is no burning, there is no measurable decline in the yield, although of course its production is very low. When you compare the burned field, the effect of burning continued maybe only one to three years, and then declined. As far as unburned land preparation was conducted, there is no significant decline with continuous cultivation. This experiment is still going on so new results will come in five to seven years later showing what the impact is of the change in the fallow period.

Now I will switch from the damage to crop production to food consumption. This shows the monthly staple food consumption by sources. In site A where the damage was very severe the major source of staple food became food purchased with cash. This shows the monthly vegetable and fruit consumption by sources, and where the main staple food was purchased with cash. At site A, the collected food from wild bushes is quite large, to partly compensate for the shortage in food. This diagram shows the change in food consumption after the 2007 heavy rainfall. It results from the intensive household survey. After crop damage, the brown line shows the value of food consumption, and the green line shows the calorie intake. After crop damage the maize failed, and then the consumption level in value declined, and you can see that it peaked at this point because the regional food supply became short which increased the food price locally. Then when the food price is very high the food consumption level in calorie base declined sharply at the same time. What is the implication of this? This is just before the harvest, so for the farmers in this region their stock does not usually last for the next harvest season. They have a short lean period where the food stock is zero. At this point, a food price hike gave a very severe impact, especially to the rural poor who have no choice but to purchase food with cash. This diagram shows that it took almost one and a half years for the food consumption levels to recover. This table shows the recovery speed of food consumption in calorie intake and its determinants. Dividing rich and poor households depending on the average livestock holdings, you can see what is really affecting the recovery of the food consumption levels. For the rich households, assets such as livestock and the education levels had a positive impact on recovery speeds. For the poor households, the cropping area was positive but the household size was negatively affecting recovery speed. Also, an older household head for rich households and a younger household head for poor households increased recovery speed.

Next I will move to health and nutritional status. This diagram shows the change in weight and food consumption after the 2007 heavy rain. The orange line shows the body weight deviation from the mean for men, and the blue line shows it for women. When the food price hike occurred, body weight for both men and women declined equally. As you have seen, the food consumption level declined and at the same time the body weight of both men and women declined sharply.

Next I will talk about other factors affecting food consumption. This shows the coping strategy after the 2007 heavy rain. At site A, about 30% of the agricultural land was abandoned because of the flood and 54% of the land was replanted by maize. Other households who could not sell maize due to crop damage after heavy rain switched to alternative income-generating activities. This is the situation before the shock, and this is the situation after the heavy rain in 2007. More activities in vegetable and livestock sales started, and the red arrows show the new activities that farmers started. This kind of flexibility of income-generating activity is quite important.

In addition, I would like to explain how the mobile phone is used these days in the rural villages. This shows what kind of transactions they are carrying out using the mobile phone. Several years ago when we started going to Zambia, mobile phones were very expensive, about US$60-70. But this summer I visited the same village and they had a phone sale. The cheapest phone is already available at US$10, so the price is declining very rapidly. Many famers already own a cell phone and they use it to talk with relatives and children. And the rural villagers in case of emergency often call relatives and sons or daughters living in major towns. Lusaka is the capital and Monze, Siavonga and Maamba are nearby towns. They call those people living in those towns to request cash, food or other items. This kind of communication has become very cheap these days. Whether the cell phone is helping people for resilience is uncertain; more research is needed. One thing I noticed is that the cash that they have to spend for talk time is getting very large. I talked to my friend living in Lusaka who said that he will spend about four to five dollars every day just for purchasing talk time, which sounds quite big considering the living standard of Zambian people.

This shows a large-scale spatial analysis, with an extensive survey of 1,000 households. We asked farmers in the southern and eastern provinces: what is your major coping strategy when you had a drought? This green shows the southern province and the blue shows the eastern province. In the southern province, the dominant strategy against drought was reducing the number of meals, because it is a no-cost strategy. So it is easy for them. But in the eastern province they had work on other farms. They had more job opportunities. So the dominant strategy was getting cash income. Not only for the southern province farmers; we considered resilience indicators for a regional comparison.

The first half of my talk was more on the short-term recovery but now I would like to talk about long-term adaptive capacity. These resilience indicators show more on long-term adaptive capacity. To do this, we used the FAO's proposed methodology of a latent variable model (Alinovi et al, 2008). Resilience to food insecurity is specified as a weighted sum of the following latent variables: access to food, asset, and safety net, access to basic services, agro-tech practices, adaptive capacity, and stability in consumption. It is a two-stage factor analysis methodology. The first step is to utilize the observed variables into latent variables. The second step is utilizing the latent variables as proxy variables to create a resilience index.

These are some of the results of the resilience scores. Comparing the sectors, households in the agricultural sector are the least resilient. Also, comparing the agricultural sector at different scales of production, the smallest scale farmers are the lowest resilience group. Comparing the components of resilience by household, you can see clearly that female-headed households are less resilient. Especially what is different is access to food, cash-earning ability and adaptive capacity which includes diversification of the livelihood and the education level and technological practices that includes the availability of extension services and so on.

We mapped these resilience scores, as indicated in this map of Zambia. Darker areas are with higher resilience. The city of Lusaka, major urban center, has quite high resilience. The frontier regions are less resilient.

If you look at resilience from a historical perspective, there are many things going on. For example, in Zambia in 1982 the government declared that farmers can enter the forest and clear the forest. Quickly, farmers went into the national reserve and opened the agricultural land, clearing the forest and destroying the forest reserve. Traditional group cultivation was on the decline; the land security decreased; contract cultivation was on the rise; and micro-finance came in, utilizing pump-irrigation and other technologies.

We have researchers who have been working on particular areas for the last 10 years, so they can consider how the farmers' resilience has changed. The vulnerability expanded, and resilience increased. So this kind of research is quite important, not only looking at production itself but many other complex factors are involved and influence the production system itself. The message from this figure is that you need to understand the changing society—not only one aspect but many factors as a bundle. That is an important thing.

Now I will return to the summary. Resilience in SAT context can be defined as the short-run recovery of food consumption, food production and livelihoods. In the long-run, resilience can be defined as the adaptive capacity of a household, community and region to absorb shocks, adapt to changing conditions and to learn, innovate and transform. Various assets including technology, livestock and land holdings and cash income opportunities are crucial for recovery of households and communities. Access to diverse resources helps households to recover from shocks more quickly. For example, the availability and the access to ecosystem services that supply wild food during the lean period. Strengthening the social safety net in different levels is necessary to increase adaptive capacity. Development of infrastructure that enables households to access markets, as well as for stabilizing food prices in the region is important.

For enhancing resilience, social systems and ecological systems sometimes change or transform at a different rates. Comprehensive approaches and long-run observations are necessary to understand complex responses and feedback due to environmental and socio-economic factors affecting rural households. For enhancing adaptive capacity of individuals and households, long-term strategies are required to improve basic services such as education, medical services, public roads and transport. To prepare for uncertainty, not only increasing specific resilience against climatic change and/or disaster risks but also increasing general resilience of the society is required in the long-run.

My last message is as follows. Food security is more than food production. A more comprehensive approach to food security is required including production, consumption and market, and with health/nutritional status.

Chairman: Thank you very much, Prof. Umetsu for your very nice presentation.