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Vulnerability and Resilience of Social-Ecological Systems

社会・生態システムの脆弱性とレジリアンス

FY2009 FR3 Project Report

平成 21 年度 FR3 研究プロジェクト報告

Project E-04 (FR3)
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Project Leader: Chieko Umetsu
プロジェクトリーダー　梅津　千恵子

March 2010
2010 年 3 月

Inter-University Research Institute Corporation, National Institutes for the Humanities
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Preface

Fiscal year 2009 is the third year of five-year RIHN Full-Research (FR) for our project "Vulnerability and Resilience of Social-Ecological Systems." Our project is a member of Ecosophy program under the five RIHN research programs. Other programs include Circulation, Diversity, Ecohistory and Resources.

During the FY2009, young project researchers stayed for long-term in Zambia and collected data with great efforts. During this fiscal year, we experienced 2nd rainy season and the harvest season for the 3rd rainy season 2009/2010 is approaching. The field experiment for the impacts of various fallow systems on agricultural yield and soil nutrients is underway at the field site in Petauke District, Eastern Province. In the Sinazongwe District, Southern Province, annual rainfall for the 2007/2008 cropping season was twice the normal level and it has been revealed that household reduced food consumption after the heavy rain. It was observed that farmers were trying to overcome this situation through various coping strategies including shifting cropping patterns from maize to potato and beans, or engaging in various cash earning activities. The analysis at the local level for decision making process of food distribution by government organization is under way. The land use and forest cover information using satellite data and aerial photographs as together with intensive ground survey analysis is also underway.

In April, eight project members attended IHDP Open Meeting 2009 and presented at two organized sessions and a poster session. In August, we organized the 2nd Lusaka Workshop and invited Dr. Elizabeth Colson who is Emeritus Professor of U.C. Berkeley and the Tonga study expert. Participants included researchers from universities and government agencies, staff from NGO and international aid agencies. The concept of "resilience" has been well received by participants of the workshop. In October, we were excited to hear news that Prof. Elinor Ostrom became a recipient of Nobel Prize in Economic Sciences. Prof. Ostrom was a lecturer of the 12th Resilience Seminar in 2006.

Our project has just finished the third year of full-research. We appreciate our project members for their efforts and contributions to the steady progress of our project. We also appreciate the Project Evaluation Committee (PEC) members, director, program directors, administrative staff and the colleagues of RIHN for their kind support and for facilitating this integrated research program.

March 2010

Chieko Umetsu
E-04(FR3) Project Leader
Research Institute for Humanity and Nature, Kyoto, Japan

E-04 (FR3)

Vulnerability and Resilience of Social-Ecological Systems

Project Leader : Chieko UMETSU Short name : Resilience Project
Home page : http://www.chikyu.ac.jp/resilience/
Keywords : resilience, poverty, social-ecological system, resource management, environmental variability, vulnerability, human security, semi-arid tropics, adaptive capacity

SUMMARY OF RESEARCH OBJECTIVES AND CONTENTS

1. Research Objectives

The objective of this research is 1) to consider impacts of environmental variability on vulnerability and resilience of human activities in the semi-arid tropics; 2) to study factors affecting social-ecological systems and their recovery from shocks; 3) to analyze factors determining ability of households and communities to recover from environmental shocks and the roles of institutions in improving household resilience; and 4) to identify the factors affecting resilience of social-ecological systems and ways in which the resilience of subsistence farmers in the semi-arid tropics to environmental variability can be strengthened.

2. Background

A vicious cycle of poverty and environmental degradation, such as forest degradation and desertification, is a major cause of global environmental problems. This is especially the case in the semi-arid tropics (SAT) including Sub-Saharan Africa and South Asia, where a majority of the world's poor are concentrated. Within the SAT, 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. Thus in this project we consider society and ecology as one social-ecological system and empirically analyze its resilience.

3. Research Methods

a. Research Contents and Methodology

The research is organized into four themes focusing on different dimensions of resilience. Theme I investigates the influences of ecological resilience on human activities by comparing soil properties in different landscapes (e.g. valleys, hill slopes and plains), the types and histories of land use, and agro-ecological succession. Theme II evaluates household resilience in risky environments in terms of income-smoothing, consumption-smoothing, and nutrition status. Theme III focuses on the institutional aspects of social resilience in the SAT. It examines how social, political, economic and ecological changes shape social resilience. Theme IV clarifies the relationship between ecological vulnerability, resilience and human activities, through investigations of historical and spatial changes in land use and multi-level social-ecological systems.

b. *Research Areas*

The primary study sites are in the drought-prone Eastern and Southern provinces of Zambia, Southern Africa (Figure 1). Minor study areas are located in Burkina Faso, West Africa, and India, South Asia.

4. Project Organization

Research Organization

The four themes interlink and thus provide a comprehensive assessment of resilience of social-ecological systems

Theme I: Ecological resilience and human activities under variable environment

Theme II: Household and community responses to variable environment

Theme III: Political-ecology of vulnerability and resilience: historical and institutional perspective

Theme IV: Integrated analysis of social-ecological systems

5. Research goals in FY2009

- Clarification of the factors controlling maize yield in the field experiments in Eastern and Southern Province, Zambia
- While continuing the household survey, anthropometric measurements, and rainfall recording that were initiated in November 2007 (the onset of the rainy season of 2007/08), we will start analyzing the impact of the variability of rainfall on household consumption and nutritious condition. In addition, we will conduct an agronomic study in order to determine the relationship between rainfall variability and maize yield at the farmers' field level.
- Continuation of field research on livelihood in intra-village activities (agriculture, forestry, animal husbandry) with respect to increasing vulnerability of rural areas and village-urban economic activities (labor migration, networking). Furthermore, we conduct research on land tenure systems which is the foundation for rural resource use.
- Multi-temporal and spatial change analysis caused by environmental change in 2008-09 and its effects for household's livelihood and food aid activities by the Zambian Government and NGO in Sinazongwe intensive research sites.

6. Progress up to Now

During the FY2006 (PR) we focussed on establishing research collaborations with various institutions in Zambia. During the FY2007 (FR1) we prepared experimental field sites and installed monitoring equipment such as weather stations, on-farm rain gauges and soil moisture measurement devices. Comprehensive household surveys and monitoring of rainfall and crop growth commenced in November 2007. During of the FY2008 (FR2) the first cropping season of 2007/2008 was completed. During of the FY2009 (FR3), the second cropping season of 2008/2009 was completed and harvest season of the third cropping season 2009/2010 is expected to start in March/April 2010.

- 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 2). 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 by agricultural households.

- The field experiment in Eastern Province revealed that pattern of soil nutrients release and weed growth differed according to the duration of cultivation, which in turn affected maize yield. Compared to the first year, more nutrient was released at the initial stage of maize growth and weed grew more rigorously in the second year. As a result, maize yield did not differ in both years. Field experiment in Southern Province suggested that annual variation of maize yield was influenced by topographical position of the fields. Field at the top of the slope had the better yield in the year with much rainfall, while that at the bottom of the slope had the reduced yield in the year with much rainfall.
- The 2007/08 rainfall was extraordinarily heavy, but its damage depends on household and the impact of these rainfall events depends on household characteristics based on the information from our local level precipitation data at the field level. Moreover, our household survey found a significant reduction of food consumption among households who suffered heavy rainfall. The anthropometric measurements, on the other hand, confirm a pattern of seasonal change in body weight.
- Field experiments in the Southern Province suggest that annual variation of maize yields were influenced by topographical context of the fields. In upper terrace (Site C), fields at the top of the slope had better yields in high rainfall years, while fields at the bottom of the slope had lower yields in high rainfall years.
- Based on a GIS analysis of damaged fields during the 2007/2008 rainy season, flood damages are concentrated in poorly-drained fields in lower terrace areas (Site A), steep fields in mid-escarpment (Site B), and valley bottom fields in the upper terrace area (Site C). We also measured the area of damaged fields for each household.
- After floods, farmers responded by replanting maize, shifting from maize to potato and beans, getting cash income from livestock sales, engaging in season activities such as fishery and wage labor to offset a shortfall of income, which indicated various coping mechanisms by affected households.
- We organized resilience seminars and workshops. In August, we held the 2nd Lusaka Workshop “Towards Resilience of Rural Households in Drought-prone Areas” and invited participants from Zambia and neighboring countries. In March, we organized Tsunami Workshop in Singapore.
- Project annual reports, working papers and a Japanese translation of a resilience workbook by Resilience Alliance, are all available at the project web site.
http://www.chikyu.ac.jp/resilience/publication-W_e.html
- At IHDP2009 Open Meeting in Bonn, two sessions were organized by the Resilience Project. Eight project members presented at the meeting. Also three project members became members of IHDP committee and sub-committee of Science Council of Japan.

7. Research Plan until the next PEC Meeting in FY2010

For the next two years of research (FR4, FR5), we plan to conduct the following:

1. While refining the theoretical aspects of resilience, we need to consider the practical applicability of the resilience approach based on the field research.
2. Integration of the research and data should be accelerated for the common goal for analyzing resilience of the farm households qualitatively and quantitatively.
3. For FY2010 and early FY2011 weather monitoring, plot experiments, household surveys, and the accumulation, compilation and analysis of data sets will be continued.
4. The first monitored 2007/2008 cropping season was an abnormal flood year, against which the 2008/2009 cropping season should be compared.
5. Coping strategies of farm households for environmental changes will be analyzed and assessed qualitatively and quantitatively.
6. To provide feedback to the local community we provided rainfall information for the first cropping season 2007/2008 to local farmers. We will continue to do so.
7. We prepare for the RIHN International Symposium and RIHN Forum for FY2011. We also prepare for working workshop for book publication.
8. Collaboration with other international research organizations should be enhanced.
9. The concept of resilience can be applied to other RIHN project as well. We continue promoting inter-project initiatives within RIHN projects and other research groups.

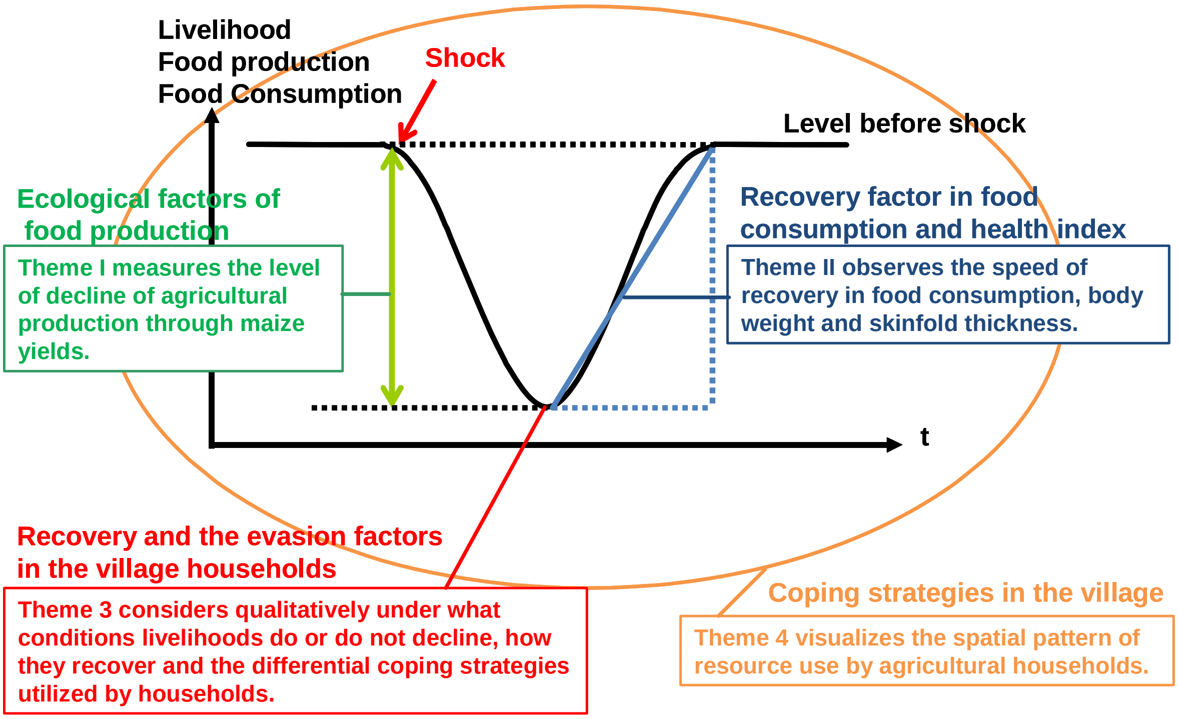
8. Research Activities from FY2006 to FY2011

Time Schedule

	2005 FS	2006 PR	2007 FR1	2008 FR2	2009 FR3	2010 FR4	2011 FR5
Research Methodology	xxx	xx	xx	x			
Zambia							
I. Ecological Resilience	x	xx	xxx	xxx	xxx	xx	x
II.Household/Community	x	xxx	xxx	xxx	xxx	xx	x
III. History/Institution	xx	xx	xxx	xxx	xxx	xxx	x
IV. Integrated Analysis	x	xx	xxx	xxx	xxx	xxx	xxx
India		x	x	x	x		
Burkinafaso			x	x	x	x	
International Workshop			x		x		x
Project Report	FS Report	PR Report	Annual Report	Interim Report	Annual Report	Annual Report	Final Report

Figure 1. Regions of Semi-Arid Tropics and Study Areas

Figure 2. Approaches to Resilience



E-04 (FR3) Project Member List (FY2009) revised 7 February 2010

	Name	Affiliation	Department	Title	Field	Role
Leader	Chieko UMETSU	RIHN	Research Department	Associate Professor	resource & environmental economics	Regional analysis, farm survey
A	Shigeo YACHI	Center for Ecological Research, Kyoto University		Associate Professor	mathematical ecology	Advisor
	Theme I					
○	Hitoshi SHINJO	Graduate School of Agriculture, Kyoto Univ.	Division of Environmental Science and Technology	Assistant Professor	soil science	organic materials and soil fertility
	Kaoru ANDO	Graduate School of Agriculture, Kyoto Univ.	Division of Environmental Science and Technology	Graduate Student (MS)	soil science	organic materials and soil fertility
	Reiichi MIURA	Graduate School of Agriculture, Kyoto Univ.	Division of Agronomy and Horticulture Science	Lecturer	botany	grass/herb components and its succession
	Masako MIYASHITA	Graduate School of Global Environmental Studies, Kyoto Univ.	Terrestrial Ecosystems Management	Graduate Student (MS)	agronomy	Landuse and risk management
○	Hidetoshi MIYAZAKI	RIHN	Research Department	Project Researcher	soil science	measurement of land plot, crop components
○	Moses MWALE	Mt. Makulu Central Research Station, Zambia Agricultural Research Station	Ministry of Agriculture and Cooperatives	Vice Director	soil science	soil analysis
	Shozo SHIBATA	Field Science Education and Research Center, Kyoto Univ.	Kamigamo Experimental Station	Professor	forest ecology	tree/shrub components and its succession
○	Ueru TANAKA	Graduate School of Global Environmental Studies, Kyoto Univ.	Terrestrial Ecosystems Management	Associate Professor	agronomy	Landuse and risk management
	Theme II					
○	Takeshi SAKURAI	Hitotsubashi University	Institute of Economic Research	Professor	development economics	household survey and analysis
	Hiromitsu KANNO	National Agricultural Research Center for Tohoku Region	Laboratory of Agricultural Meteorology	Team Leader	agricultural meteorology	measurement of rainfall data
	Hiroyuki SHIMONO	Faculty of Agriculture, Iwate University	Crop Science Laboratory	Associate Professor	crop science	Crop Science Modelling
	Taro YAMAUCHI	Graduate School of Health Sciences, Hokkaido Univ.	Devision of Health Sciences	Associate Professor	human ecology	human growth, nutrition and health
	Sayuri KON	Graduate School of Health Sciences, Hokkaido Univ.	Devision of Health Sciences	Graduate Student (MS)	human ecology	human growth, nutrition and health
	Theme III					
○	Shuhei SHIMADA	Graduate School of Asian and African Area Studies, Kyoto University	Division of African Area Studies	Professor	environmental geography	village society and institution
	Minako ARAKI	Faculty of Letters and Education, Ochanomizu University	Geography	Associate Professor	development study	village society and institution
	Kazuo HANZAWA	College of Bioresource Sciences, Nihon University	Department of International Development Studies	Professor	agricultural economics	farm household survey
○	Yudai ISHIMOTO	RIHN	Research Department	Project Researcher	ecological Anthropology	emergency food of farm household
	Chihiro ITO	Graduate School of Asian and African Area Studies, Kyoto University	Division of African Area Studies	Graduate student	human geography	labor migration in rural area
	Gear M. Kajoba	University of Zambia	Department of Geography	Senior Lecturer	geography	land tenure system and food security
	Shiro KODAMAYA	Graduate School of Social Sciences, Hitotsubashi University	Division of African Area Studies	Professor	African sociology	agricultural development and social change
	Akie KYO	Graduate School of Asian and African Area Studies, Kyoto University	Division of African Area Studies	Graduate student	palliative medicine	co-existence with sickness and care
	Chileshe MULENGA	University of Zambia	Institute of Economic and Social Research	Senior Lecturer	economic geography	analysis of social behaviors
	Noriko NARISAWA	Graduate School of Asian and African Area Studies, Kyoto University	Division of African Area Studies	Graduate student	gender anthropology	economic activities of female farmers
○	Masahiro OKAMOTO	RIHN	Research Department	Project Researcher	anthropology and area studies	Local community and subsistence sysytem
	Theme IV					
○	Mitsunori YOSHIMURA	Remote Sensing Technology Center of Japan (RESTEC)		Senior Researcher	remote sensing	ecological change monitoring
○	Thamana LEKPRICHAKUL	RIHN	Research Department	Senior Project Researcher	environmental & health economics	household survey and analysis
	Keiichiro MATSUMURA	Graduate School of Human and Environmental Studies, Kyoto University	Cultural, Regional and Historic Studies on Environment	Assistant Professor	cultural anthropology	land tenure system and rural livelihood
	Tazu SAEKI	National Institute for Environmental Studies	Center for Global Environmental Research	NIES Assistant Fellow	atmospheric physics	climate monitoring
	Chieko UMETSU	RIHN	Research Department	Associate Professor	resource & environmental economics	regional analysis
	Megumi YAMASHITA	Survey College of Kinki		Lecturer	geographic information	vegetation monitoring
	India					
○	K. Palanisami	International Water Management Institute	IWMI-TaTAs Program	Program Coordinator	agricultural economics	household survey and analysis
	B. Chandrasekaran	Tamilnadu Agricultural University	Directorate of Research	Director	agronomy	rice production analysis
	V. Geethalakshmi	Tamilnadu Agricultural University	Department of Agricultural Meteorology	Professor	agriculatural meteorology	monsoon rainfall analysis
○	Takashi KUME	RIHN	Research Department	Senior Project Researcher	soil hydrology	tsunami impact study
	C.R. Ranganathan	Tamilnadu Agricultural University	Department of Mathematics	Professor	mathematics	economic modelling
	Akiyo YATAGAI	RIHN	Research Department	Assistant Professor	climatology meteorology	monsoon rainfall analysis
	Burkina Faso					
	Kimseyinga Savadogo	University of Ouagadougou	Department of Economics	Professor	economics	household data analysis
	Tom Evans	Indiana University	Department of Geography	Associate Professor	geography	agent-based modelling

○＝Core Member; A = Advisor; MAFF=Ministry of Agriculture, Forestry and Fisheries

Resilience of Rural Households in Africa: An Introduction

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[2]Graduate School of Agriculture, Kyoto University, Kyoto Japan
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[4]Graduate School of Asian and African Area Studies, Kyoto University, Kyoto Japan
[5]Remote Sensing Technology Center of Japan, Tokyo Japan

Introduction

The term *resilience* originates from the Latin word *resilire* which means "to leap back". Resilience is defined as "the ability of a system to absorb shocks, to avoid crossing a threshold into an alternate and possibly irreversible new state, and to regenerate after disturbance" (Resilience Alliance, 2007). Resilience, in other word, means the amount of disturbance that the system can endure without changing the original steady-state and without moving into an alternate regime. Social-Ecological systems have certain thresholds that are important for considering the system resilience. Social-Ecological systems also show reversible and sometimes irreversible regime shifts in time scale with societal implications. More resilient systems are considered to have an ability to absorb larger disturbance without moving into an alternate regime (Gunderson 2003; Walker 2004).

The concept of ecological resilience has been a focus of ecological research since defined in the seminal paper "Resilience and Stability of Ecological Systems" by C. S. Holling (1973). The earlier concept of resilience is called *engineering resilience* where resilience is defined as the recovery time for an ecological system to return to the initial equilibrium condition present before disturbance. Systems that return to initial equilibrium conditions more quickly are considered to be more resilient that systems that take a long period to recover after disturbances. The equilibrium concept was expanded to the concept of *ecological resilience*, which emphasizes capacity to endure disturbance, incorporating non-linearity, multiple equilibria and regime shifts. After the 1990s, the resilience concept focuses more on the properties of self-organization after disturbance. Recently researchers applied these resilience concepts used in ecology and engineering to complex social-ecological systems (Levin et al., 1998; Levin, 1999; Berkes, Fikret & Folke eds., 1998; Berkes, Colding & Folke eds., 2003). Resilience is a particularly relevant concept for considering the recovery of communities affected by disasters and the development of rural societies whose livelihoods are highly dependent on natural resource base.

The development of 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 accordingly had less focus on critical development issues such as poverty and environmental degradation in developing world. Furthermore, conventional development economics tend to ignore ecosystem services that are 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 in order to address development issues such as resource degradation and to enhance human security. Important concepts for considering resilience involve threshold, regime shift and redundancy.

Various methods for quantifying resilience have been developed. Briguglio (2005) defined economic resilience as follows: a) to recover quickly from a shock; b) to withstand the effect of a shock; c) to avoid the shock altogether. Briguglio (2005) first tried to quantify economic resilience using indicators of macroeconomic stability, microeconomic market efficiency, and good governance. Adger (2000) defined social resilience as "the ability of groups or communities to cope with external stresses and disturbances as a result of social, political, and environmental change". Washington-Allen et al. (2008) attempted to quantify ecological resilience by using remote sensing analysis to estimate vegetation productivity in dryland ecosystems. Although resilience is defined and analyzed in both economic and ecological terms, their integration is still under development. The recent resilience literature has begun to apply this concept directly to development issues (Mäler 2008). The recent report *World Resources 2008: Roots of Resilience—Growing the Wealth of the Poor* published by the UNDP/UNEP/WB/WRI clearly indicates that resilience is one of the goals that communities need to achieve through economic activities and in the course of development. Despite selected recent efforts (Resilience Alliance 2007), the method of evaluating resilience is still not well defined in the current literature compared to vulnerability (Gallopin 2006). The purpose of this introduction is to address approaches to study resilience we employ in our Resilience Project.

Operationalizing Resilience

In the Semi-arid Tropics (SAT) (Thornthwaite 1948; Megis 1953; Troll 1965; Ryan and Spencer 2001), 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 depend largely on vulnerable rain-fed agriculture. Food security and poverty reduction are critical issues. 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). 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.

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).

Resilience and Human Security

Resilience in the context of protecting survival, livelihood and dignity of households and communities is considered as follows (Figure 1):

Survival

-The ability of the household (subsistence farmers) to recover from a shock (e.g. drought) to sustain their survival.

Livelihoods

-The ability of household and community to recover from a shock and maintain their agricultural production and livelihoods. This involves the recovery of agricultural production and household income by shifting to other source of income.

Dignity

-The ability of household and communities to recover from a shock to maintain their living environment that does not endanger their dignity.

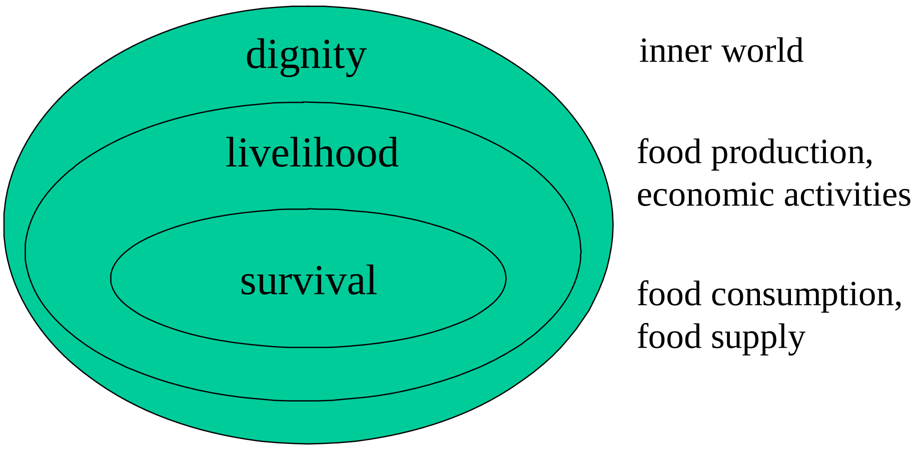

Figure 1. Human security for survival, livelihood and dignity

Approaches to Resilience

In Resilience Project, four themes employ different 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 2). Theme 1 measures the level of decline of agricultural production through maize yields (Shinjo et al.; Kuramitsu et al.; Sokotela et al.; Miyazaki et al. in this issue). Theme 2 observes the speed of recovery in food consumption, body weight and skinfold thickness (Sakurai et al.; Yamauch and Kon; Kanno et al.; Shimono et al. in this issue). Theme 3 considers qualitatively under what conditions livelihoods do or do not decline, how they recover and the differential coping strategies utilized by households (Shimada 2009; Ito 2009; Nakamura 2009; Kajoba 2009; Mulenga 2010; Ishimoto in this issue). Theme 4 visualizes the spatial pattern of resource use by agricultural households (Yamashita et al.; Miyashita et al.; Matsumura in this issue). This theme also includes spatial resilience (Evans and Caylor in this issue) and historical investigation (Thamana et al. in this issue). For a major disaster, the social-ecological system has possibly shifted to alternative state in case of 2004 Indian Ocean tsunami (Kume 2009; Palanisami et al. in this issue).

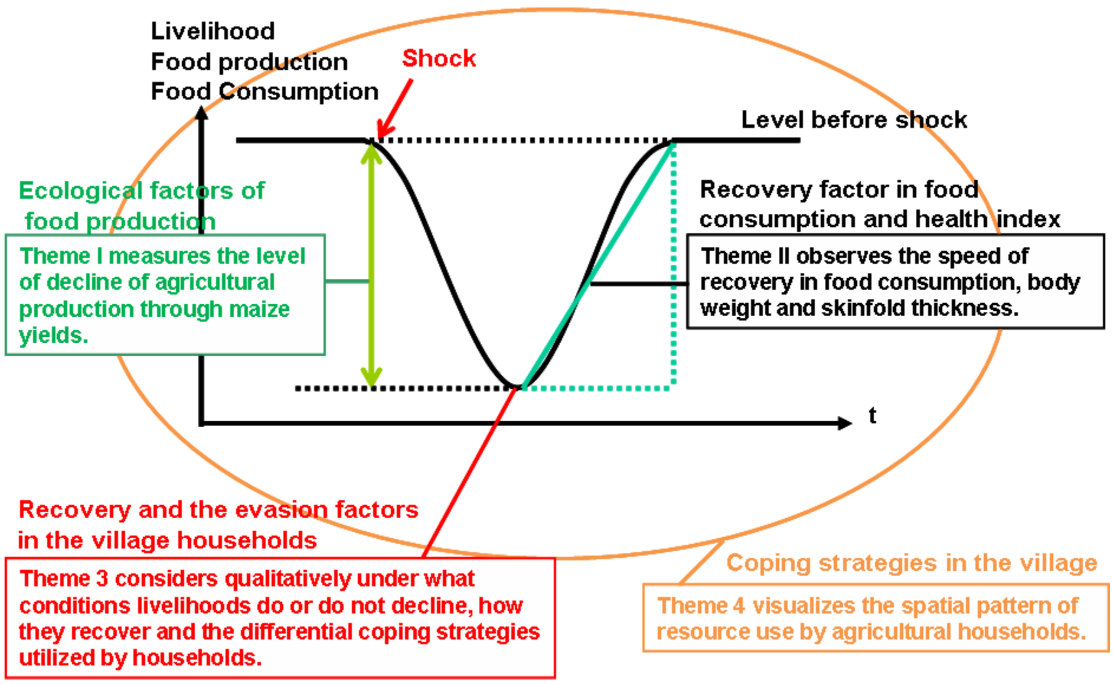

Figure 2. Approaches to Resilience

Indicators and Factors Affecting Resilience

In case of emergency such as drought, the most important mission is to secure food supply for survival. The resilience of social-ecological system for subsistence agricultural households in SAT is resilience *to* environmental variability, *of* food supply and consumption, health status, agricultural production and livelihoods, and *for* protecting human security, i.e., survival, livelihoods and dignity. Figure 3 indicates our research components and indicators of resilience. This figure illustrates the relationship between 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 green. 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. 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 decline of food consumption will affect the health and nutritional status of household members. The decline of food consumption especially affects children under 5 years old and causes a decline in health condition as estimated from their body weight and skinfold thickness. When food supply from their own fields declines, household heads try all measures to secure food supply for the household from other means. Options include the sales of cash crops such as vegetables, or switching to alternative agricultural activities such as hunting, collecting wild food, fisheries, and livestock production. 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, but social networks such as relatives and friends also play an important role. Even though food production declines in drought years, households employ various coping strategies and alternative economic activities to try to recover from these shocks. In addition, regional scale dynamics are 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.

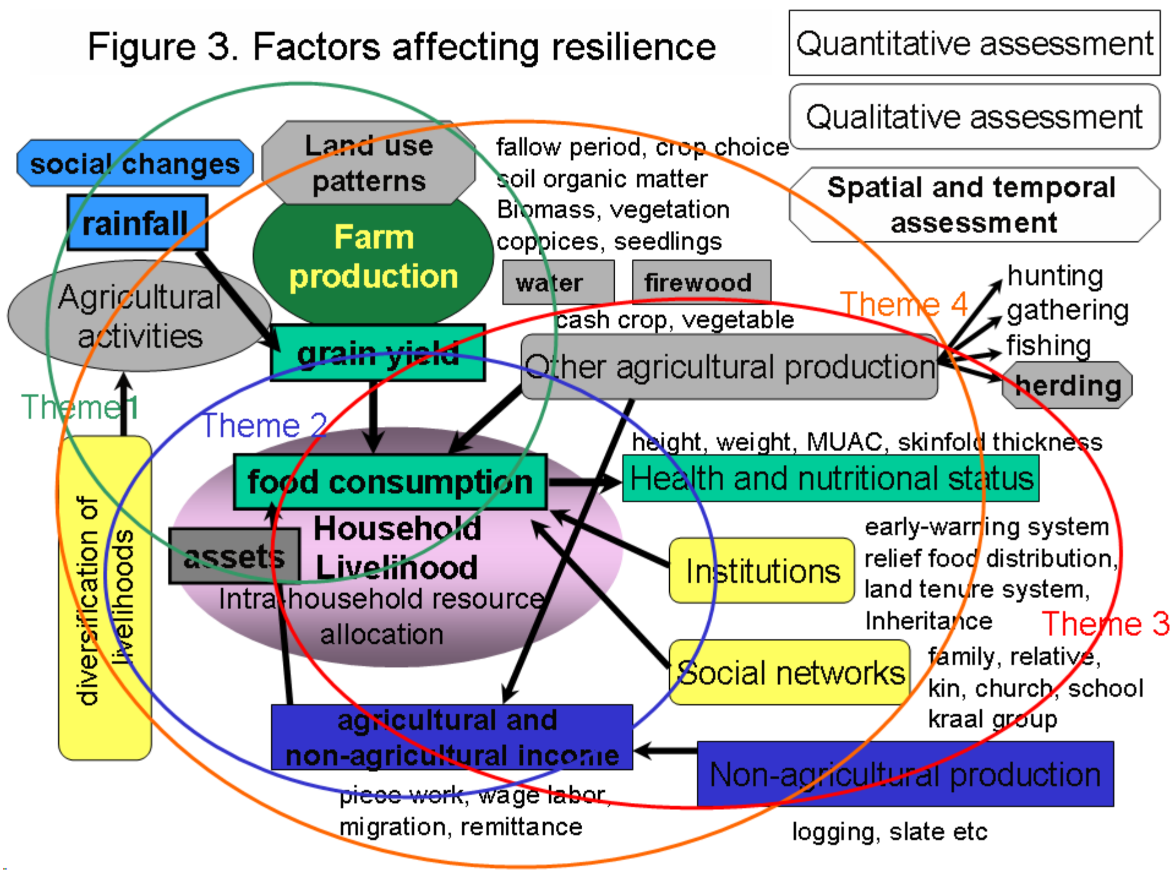

Figure 3. Factors affecting resilience

Conclusion

This paper tries to provide an overview of our 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. 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 of a society to build sustainability at all levels.

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Weed Vegetation in a Slash-and-burn Experimental Plot in Eastern Province, Zambia, and the Germination Characteristics of Two Dominant Grass Weed Species

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Abstract

A weed vegetation survey was carried out in April 2009 in the experimental station in the Eastern Province of Zambia where a plateau-type miombo forest had been turned into a series of slash-and-burn fields. The whole plot included subplots that were reclaimed in 2007 and 2008, i.e. the subplots were in the second and first year of cropping, respectively, at the time of the survey (the 2008/09 growing season). The sites where cut forest trees were piled and burnt were marked out in each subplot and analyzed separately. All plots were planted to maize at a uniform density of 1 hill m^{-2}.

A 1 m × 1 m quadrat was placed on one each maize hill, which was offset by 1 m from the maize hill used for the measurement of maize growth and yield to avoid any experimental interference, yet enabling spatial correlation analyses between maize yield and weed biomass in the future. The plant height and coverage of each species in the quadrat were visually scored and then the whole weed biomass in the quadrat was harvested, separated into herbaceous and woody components, dried in paper bags under sunlight for one week and weighed. The multiplied dominance value (MDV), which is the product of plant height and coverage of each species, was used to describe and analyze the species composition of the weed vegetation.

The weed biomass was significantly higher in the plots in the second year of reclamation than those in the first year. The weed biomass was markedly lower in burnt areas even in the second year. The most dominant weed species was *Diplorhynchus condylocarpon* (a resprouting species) in the first year and *Melinis repens* in the second year. The plots that were cropped in the first year and were returned to fallow in the second year accommodated three times the weed biomass per area of continuously cropped plots. Detrended correspondence analysis identified *Cyperus* sp., *Acalypha* sp. and *Hyparrhenia filipendula* as remnants of the miombo undergrowth, while *M. repens*, *Bidens schimperii* and *Hyparrhenia anamesa* were characterized as agrestals.

The seeds of the two most dominant grass weeds, *H. anamesa* and *M. repens*, were collected and subjected to germination tests after storage under several different conditions. Seeds of *H. anamesa* had a primary dormancy, which was broken by 199 days of dry storage or by seven days of dry heat treatment at 60˚C. *M. repens* seeds did not have a primary dormancy but showed a weak light requirement for germination.

Evaluation of Agro-forestry Plants for Soil Fertility Restoration and Enhancement of Sustainable Agriculture in Eastern Province, Zambia

-Report for the Period of 2008 - 2009 Crop Season-

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Abstract

A field trial for demonstration and evaluation of agro-forestry plants to restore soil fertility is being conducted at the plots adjacent to the RIHN plots in Eastern Province, Zambia. Good growth of agro-forestry plants were observed and farmers, village headmen, and representative of the Chief invited to the Field Day showed great interest on past achievements.

1. Introduction

Vulnerability and Resilience research work is being undertaken in Zambia to address issues pertaining to social and ecological systems in the context of mitigating adverse effects of climate change in local communities of Zambia. The Zambia Agriculture Research Institute of the Ministry of Agriculture and Co-operatives (ZARI/MACO) in collaboration with the Research Institute for Humanity and Nature of Japan (RIHN/JAPAN) established a research site in Eastern Zambia. Selected agro-forestry and green manure plant species are being demonstrated and evaluated for adaptation by local village farmers in Chief Sandwe’s area and other surrounding sites of the District since 2007. An update report is provided each year, and this report highlights the 2008/2009 crop season activities entitled, ‘Demonstration and Evaluation of Agro-Forestry Plants for Soil Fertility Restoration to enhance Sustainable Agriculture’.

2. Location and site characterization

The research site at Mwelwa village is located some 38 km north-east of the Petauke main urban centre, with geographical co-ordinate references at approximately 14^0 55’ S and 31^0 25’ E at an elevation of about 980 m above mean sea level. The area falls within the Agro-Ecological Region IIa, which is characterized by medium rainfall precipitation of about 900 mm in the average year. Like most of Zambia the area enjoys a sub-continental, sub-tropical savanna climatic and vegetation conditions, respectively. The main local vegetation comprises the *Miombo* woodland, dominated by the *Brachystegia* genera trees with *Hyperhania* grass species, as undergrowth.

The area where the demonstration study is situated represents a typical rural Zambia, in which main local socio-economic factors are traditional farming based. The agriculture system practice is the *Nsenga* type cultivation, representing a main local ethnic group, who depend on the hand-hoe, axe, and sometimes the ox-drawn plough. Local seeds of crops are used. It is rare to use modern fertilizers, but may be applied to maize if available. Land is cleared of trees using the hand axe. The cut trees are chopped down and may be piled to dry and burnt in heaps later when dry. At the onset of the rainy season fields are dug up with hoes in land preparation before planting crops. After harvest domestic stock (cattle, goats, pigs) are left to forage on the previous crop residues. The field is extended in this way each subsequent year. Old opened up fields are cultivated continuously with maize and other local crops including beans, pumpkins, groundnuts and cassava, for four to five years, then abandoned, mainly due to low soil fertility and weeds pressure. It has been observed that this traditional system of cultivation may cause deforestation and general soil and land resources degradation with the long term passage of the time.

The current study seeks to introduce an agro-forestry technology intervention of soil fertility management improvement for sustainable agriculture. Prior to establishment of the research field plots detailed site characterizations were conducted including the determination of spatial soil variability assessments, topographical and botanical plants identifications. The main soil types were classified as *Typic Plinthustalfs*.

The purpose of the work by the ZARI studies is aimed at removing conditions undermining food security and soil ecology quality in the local environment, thereby helping to build both social and ecological resilience in the region. The study serves as a demonstration to evaluate the effectiveness of agro-forestry technologies in enhancing soil health ecology resilience as measured by the efficacy of some selected agro-forestry and green manure plant species in soil fertility restoration for the enhancement of sustainable agriculture.

3. Materials and methods

Established plots were planted with *Grilicidia sepium* (Grilicidia), *Mucuna repensis* (Velvet bean), *Cajanus cajan* (Pigeon pea), in addition a Miombo woodland bush (*Brachystegia-Julbernadia* sp.) native forest fallow, and *Zea mays* (Maize), with and without fertilizer treatments. The above named species were placed under experimentation and demonstration to evaluate their effectiveness in enhancing soil health ecology resilience as measured by soil fertility improvement and restoration for sustainable agriculture.

Overall, the hypothesis that proven agro-forestry technologies help to improve soil fertility conditions would be tested through three outlined aims:

1. To demonstrate the agro-forestry species in soil fertility improvement as improved short fallow agricultural technology practices
2. To measure soil property dynamics and characteristics that occur resulting from defined practices in land use and imposed field practices
3. To asses any socio-economic impact of (long-term) benefit achieved on adoption of the technologies by various households in communities, thereby re-enforcing social and ecological resilience concepts and principles.

Trial design

The field experiment was laid out in a Completely Randomized Block Design (CRBD) with three replications (Figure 1) at a sub-plot size of 20 x 20 m^2.

F 13	D 14	A 15	C 16	B 17	E 18
A 12	C 11	D 10	E 9	B 8	F 7
B 1	E 2	C 3	F 4	D 5	A 6

↑ N

Note: A = Treatment; 1 = Sub-plot No. 1

Figure 1: ZARI Plot Layout, Mwelwa Village sketch

Treatments

A *Grilicidia sepium* fallow (GSF)

B Maize continuous fertilizer (MCF)

C Native Forest fallow (NFF)

D Maize, no Fertilizer (MoF)

E Green Manure fallow (GMF *Mucuna*)

F *Cajanus cajan* fallow (CCF)

Notes:

a) At the time of implementation each sub plot measuring 20 x 20 m^2 was composite soil sampled at two depths, the top soil at 0 – 20 cm and the subsoil at 40 – 60 cm depths, respectively. Each soil sample was taken for soil laboratory analyses for pH, Bases, CEC Organic Carbon, total Nitrogen, available Phosphate and Particle Size Distribution (PSD).

b) *Gliricidia* was initially raised in nursery beds, and later planted into the field from potted seedlings at the spacing of 1 x 1 m^2. The spacing for Pigeon pea in the field was the same as for *Gliricidia*, but the crop was direct planted in the field by seed.

c) A Hybrid maize variety MM 604 was used as a test crop and planted at the spacing of 90 cm between rows and 25 cm between stations within the rows. Fertilizer application rate followed the LIMA recommendation of 4 x 50 Kg/ha Compound D (10N, 20 P_2O_5, 10K_2O 4 – 6 S), and the same rate for Urea (46% N) as top dressing in the continuous maize with fertilizer treatment. (MCF).

d) The Native Forest fallow was left without carrying out any land clearing or preparation. The bush was left in the virgin state as it was found before implementation of the experiment.

e) The green manure plot was planted with Velvet bean (*Mucuna*).

f) On all the cultivated plots land preparation consisted of cutting down and stumping all trees, followed by digging with hand hoes well before the onset of the rainy season in October. Soil samples were taken before planting.

g) After planting crop performance monitoring activities were conducted and included replanting, weeding and scoring for disease, pests, etc.

Grain yield and stover were harvested in maize plots and measured by weight to determine the biomass yield. Pigeon pea and velvet beans were harvested from dry pods. All fields were protected from fire by clearing fire breaks around all trials plots.

3. Results and discussion

Soil properties

In general the soils were low to medium in soil fertility status for plant growth and soil reaction conditions were of strong to medium acidity ($pHCaCl_2$ 5.1 – 5.7) (Table 1). Besides having low organic C content (<2.0 %), soils showed low N and P content, with the base saturation percentage being low to medium. It was observed that initially, there was no significant difference in the soil fertility status between the native forest plot and the Maize with continuous fertilizer application. The trend was similar across all the other treatments.

Table 1 Critical values of soil fertility (standard value below which fertility level is regarded low) and analytical results from maize plot with continuous fertilizer (MCF) and native fallow forest.

		Treatment MCF		Native fallow forest	
Parameter	Critical value	Top soil	Sub soil	Topsoil	Subsoil
Ca ($cmol_c$/kg)	1.0	2.7	1.9	1.6	2.07
Mg ($cmol_c$/kg)	0.2	0.63	0.47	0.63	0.57
K ($cmol_c$/kg)	0.07	0.63	0.83	0.68	0.71
Na ($cmol_c$/kg)	NA	0.62	0.46	0.24	0.52
N (%)	NA	0.07	0.05	0.08	0.04
P	7.0	nd	nd	na	na
pH	4.5	5.4	5.6	5.4	5.5
C (%)	1.0	1.04	0.42	1.37	0.38

Biomass estimation in agro-forestry and native forest plots

Above ground plant biomass in the agro-forestry and native fallow plots was estimated by measuring plant height and stem girth (diameter) at ground level. By estimating canopy cover by plants an assessment of 'volume mass' may be achieved. A simplified way was to compare tree height and stem thickness at collar (ground) level.

Table 2 Performance of the Native Forest, Cajanus cajan and Gliricidia sepium trees

FIELD MEASUREMENTS IN EVERY 5 METRES						
	Native Forest - Plot 3		*Cajanus cajan* - Plot 4		*Gliricidia sepium* - Plot 6	
Serial No.	Average Height (m)	Average Girth (mm)	Average Height (m)	Average Girth (mm)	Average Height (m)	Average Girth (mm)
1	2.4	36.4	3.4	37.1	2.1	41.6
2	4.2	74.2	4.2	40.1	2	44.1
3	2.2	35.4	3.5	50	1.9	45.3
4	2.9	60.2	3.7	50.7	1.9	40.4
5	3.6	52.7	3.5	39.8	2.3	47.1
Av.	**3.06**	**51.78**	**3.66**	**43.54**	**2.04**	**43.7**

Table 3 Summary of performance by treatments.

a) Agroforestry and Native forest trees

Plant sp.	***C. cajan***	***G.sepium***	**N.forest**
Height (m)	3.66	2.04	3.06
Girth (mm)	43.54	43.7	51.78

b) Maize performance

Treatment.	**Cobs No.**	**Cobs Wt.(Kg)**	**Stover Wt (Kg)**	**Diseased Cobs (Fusarium)**
Plot 1 Maize with fertilizer **MCF**.	74	10.58	19.26	9
Plot 17 Maize with fertilizer **MCF**	72	7.06	18.26	16
Plot 8 Maize with fertilizer **MCF**.	81	7.54	20.7	15
Plot 14 Maize without fertilizer **M0F**	73	2.42	2.88	1.6
Plot 5 Maize without fertilizer **M0F**.	78	2.8	4.26	9
Plot 10 Maize without fertilizer **M0F**	82	3.18	4.42	4

NB: Number of cobs (5*5 m^2)

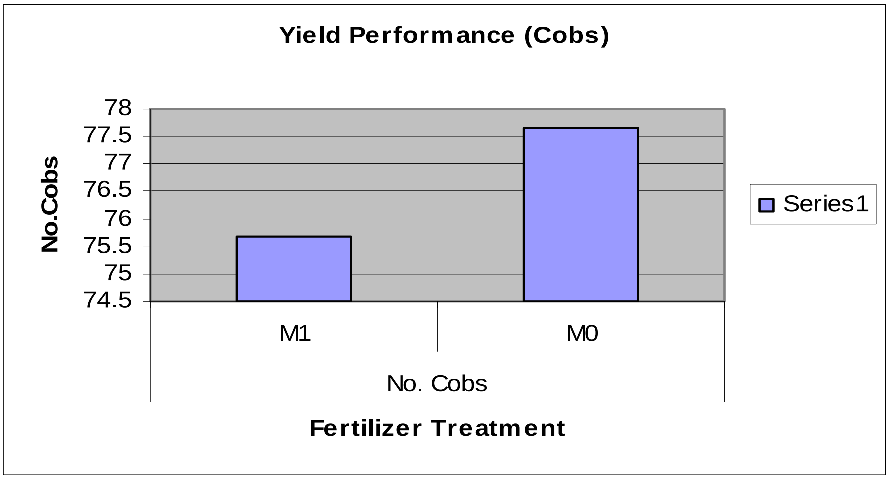
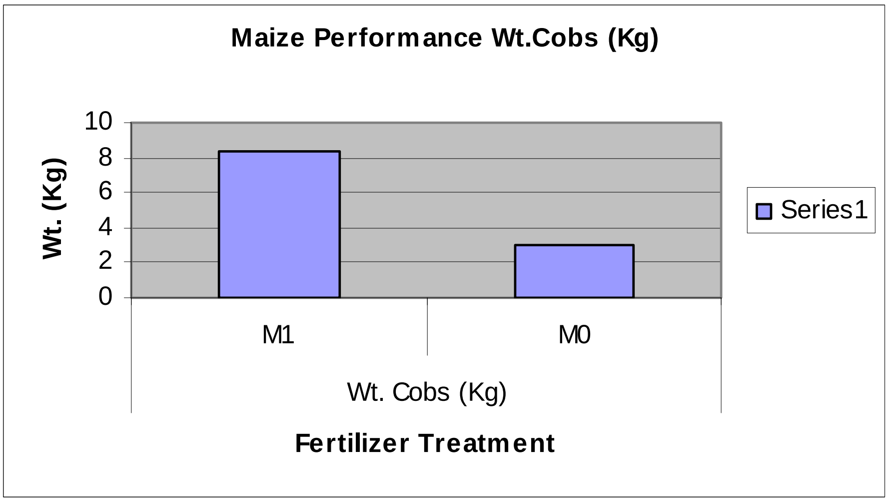
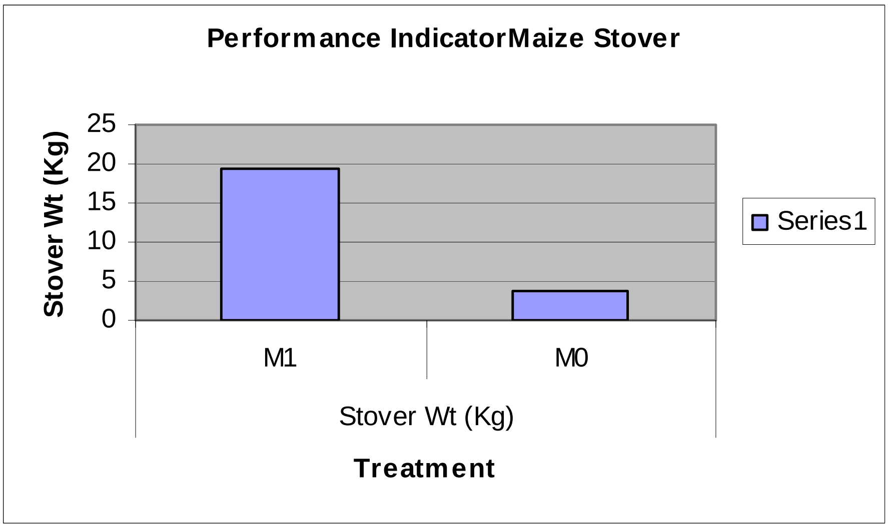


Figure 4 a) Crop performance as number of cobs, with and without fertilizer



b) Performance of maize by weight of cobs



c) Maize stover weight

It was ascertained that fertilizer application resulted in greater performance in a maize crop by cob and stover weight. However, under stress of low fertility conditions, a greater number of cobs with very low weight were produced by maize (Fig. 4 a).

Monitoring of Crop Performance

Monitoring of crop performance observations were related to general crop stand, vigour, pest, disease and/or observed nutrient deficiency (Table 4).

Table 4 Some monitored crop performance, Petauke Research Site

	Crop	**Establishment, crop stand, vigour**	**Pest type, severity**	**Disease type, severity**	**Nutrient deficiency**	**Other remarks**
1.	Maize with fertilizer (MCF)	Medium; milk stage, small to medium cob size formation	Mice 20%	Necrotic GLS (few) Streak virus (isolated)	Chlorosis, N (yellow) P (purple) Mg (green veins in leaf)	Weed pressure, Too much Rain (January)
2.	Maize without Fertilizer (MoF)	Generally small, stunted;; nothing to small cobs	-	GLS mild Necrosis	Widespread N Chlorosis; Few P Deficiency	
3.	Grilicidia (GS)	Good survival rate (90%)	-	-	-	Resilient to pest damage once established
4.	Pigeon pea (CC)	Very good, survival rate (98%)	-	Few plants infected with fungal infection from the roots.	Not observed	Very good establishment
5.	Velvet bean (VVB)	Good cover and growth	Non observed	Non observed	Non established	Very good establishment
6.	Native fallow (NC)	Bush fallow	N/A	N/A	N/A	Some mushrooms growing in association with rotten woody materials

Field Day

After the maize crop maturity and establishment of the agro-forestry and green manure plants around March/April 2009, a field day was held at the research field plots, where local farming people from nearby communities around Mwelwa village, including His Royal Highness Chief Sandwe, and Petauke District officials from the Ministry of Agriculture, and representatives from schools participated. The purpose of hosting the field day was to demonstrate and begin to disseminate agro-technology information into the local community, and consequently share a platform of understanding and appreciate of both the ZARI and RIHN research activities in the area.

4. Conclusion

It was noted that continuous heavy rainfall in January 2008, soon after top dressing in maize may have induced loss of nitrogen in MCF treatment. Replanting was necessary for all maize plots due to mice attack at germination. Initial soil fertility status is generally low to medium. Maize with fertilizer treatment out yielded the one without fertilizer by at least 25 %. The establishment for both the Grilicidia and Pigeon pea plots was successful. Velvet bean established successfully, having been grazed by wild rabbits.

The field day was highly successful with more than 12 village headmen, and the Chief Sandwe representation in attendance, more than 100 small scale farmers participated.

There was an overwhelming request for distribution of some agro-forestry plant seeds (Pigeon pea) to plant by headmen and the Chief in the coming season.

The crop for the 2009/2010 season was planted on time in 2009 and is presently under field performance monitoring stage.

Fluctuation and Controlling Factors of Maize Production under a Variety of Agroecosystems in Southern Province, Zambia (Summary)

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Abstract

To evaluate ecological resilience, field experiments were conducted. The experimental results from the past two years indicated that maize production fluctuated not only in relation to climatic variation but also with topographic and soil fertility conditions.

1. Introduction

To evaluate ecological resilience, field experiments were conducted. In this report, to understand fluctuation of maize biomass and its controlling factors, we examined the experimental results from the past two years. Details of each plot are described in the FY2007 FR1 Project Report and FY2008 FR2 Project Report.

2. General properties of the soils studied

Soil pH was generally neutral but was slightly acidic in some plots. At Site A, total nitrogen was low compared with the other two sites. All plots contained soil exhibiting a sandy texture. Exchangeable cations and cation exchangeable capacity were low. Base saturation percentages were high with the high percentage of Ca indicating that the soils are not well weathered. At Site A, available phosphorus was high even in the deeper horizons.

3. Nutrient stock at the study sites

Total nitrogen in the topsoil (0–15cm depth) was highest at the CSa2. Exchangeable potassium and available phosphorus in the topsoil were highest at the ASn1. Considering all soil depths, total nitrogen was highest at the BCh2 and exchangeable K and available P were highest at the ASm1.

4. Fluctuation of maize production

4-1. Maize production in 2007

With decreasing altitude in each site, the aboveground biomass and grain yield decreased except for BCh1 and BCh2. This decrease could be ascribed to the damage of waterlogging and excessive wetting caused by heavy rain in the lower areas.

4-2. Maize production in 2008

Total precipitation at Sites A and C in the 2008/09 rainy season were 1053 mm and 1245 mm, respectively. These values were slightly higher than the mean annual precipitation of the area, which is less than 800 mm. However, in this year, few fields were damaged by waterlogging and excessive wetting caused by rain according to all participating households interviewed. Only CSa4 was still damaged by rain. With decreasing altitude in each site, grain yield increased except at BKa.

4-3. Fluctuation of maize production between the two seasons

In 2008 the maize yield was higher in all plots except CSa1 in comparison with those of 2007. In both years, the number of established plants was lower than the number of seeds sowed. In particular, the plant number was very low in 2007 presumably due to washing away of maize seeds by heavy rain. The yield per individual maize plant in 2008 increased except at CSa1 in comparison with 2007. Annual variation in maize yields was influenced by the topographical position of the fields. At Site C, CSa1 produced better yields in high-rainfall years, while CSa4 produced lower yields in high-rainfall years.

5. Factors controlling maize production

Maize yield was well correlated with total biomass regardless of weather and soil nutrient conditions. Maize yield was correlated with soil nutrient stock in the overall soil profile, but no correlation between maize yield and nutrient stock in the topsoil was found.

6. Conclusion

A complex relationship between maize production and weather, topography and soil fertility is suggested, which will hopefully be clarified in the future by the ongoing field experiments.

Livelihood and Land Use in Some Villages of Southern Province, Zambia
- A Case Focusing on the Production of Commodities and Petit Trading by Women -
(Summary)

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1. Background and Objectives

International aid agencies, local government and NGOs seem to focus on farming of major crops such as maize in rural development assistance. Through the series of field works in southern Zambia, however, we observed that people's livelihood are supported by diverse activities including animal husbandry, maize and cotton farming, vegetable farming, petit trading and so on. It is also remarked that women's activities, which have not been carefully focused and described in the context of rural development, are significant for their household income and maintenance of daily life. Standing on such understanding, the objectives of the study were set to depict general aspects of people's livelihood and land use, and to reappraise women's roles and functions through describing the activities such as vegetable farming and petit trading.

2. Outline of the study area

Zambia has a dry season (April-November) and a rainy season (December-March) with annual precipitation between 700 mm and 1,000 mm. The study villages (Malabali, Mapobwe, Mweemba and Siachaya village) are located in the undulating terrace and sloping landscape along the road on the way from the southern highland down to Lake Kariba in Southern Province and area believed as drought-prone area due to its relatively lower precipitation of 700 mm. In reality, the record of yearly precipitation shows great fluctuation of precipitation from wetter side over 1,200 mm and to drier side down to 300 mm. Actually, flooding and over-wetting damaged crops in 2007.

3. Livelihood and land use

Major crops during rainy season are maize, cotton, sweet potato and beans for self-consumption and household income by selling. This farming is operated in the vast area of slope and ridge. The farming works in the rainy season are done by family members. Women, in addition, take duties for housekeeping such as cooking, fetching water and cleaning. Fields along shallow inland valley, not cultivated during rainy season due to the risk of flooding and over-wetting, are utilized for green maize and vegetables, e.g. rape, cabbage, tomato and onion during dry season. Women take initiative for managing vegetable fields and petit trading of the commodities from their fields.

4. Commodities and petit trading by women

We identified 35 commodities obtained year round form cultivation fields and bush land. Thirteen out of 35 were from vegetable field in dry season. Women frequently carry their commodities to marketing places for selling. Such petit trading was not only practiced in the market places, but also in the villages. Among the income sources recorded, women's petit trading shared 24% to the total household income (average of 97 households surveyed).

5. Concluding remarks

These facts revealed that women's activities are greatly significant in maintaining daily life and household economy and, therefore, to be paid more attention in rural development assistance. Existence of diverse commodities produced all year round and income sources may contribute to the resilience at household and village level.

Empirical Evidence of Resilience at Household and Individual Levels
-The Case of Heavy Rain in Drought-Prone Zone of Zambia-

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Abstract

There is a large volume of empirical literature on risk coping and consumption smoothing in the context of rural areas of developing countries where people's livelihood is always threatened by various risks. "Coping" implies the process of recovery from a shock. However, the existing literature does not consider time required for households and/or individuals to recover the level of consumption. Shortcomings of such analyses are that welfare impact of a shock can be underestimated because they cannot separate the shocks (i.e. reduction of consumption) and the recovery (i.e. increase of consumption) if recovery process starts before *ex post* data collection.

In order to improve the existing literature, this paper incorporates time dimension in the process of recovery from a shock. For this purpose, this paper adapts the concept of resilience from ecology and defines it in the context of consumption smoothing. Moreover, unlike most of previous studies on consumption smoothing, this paper utilizes weekly data collected before and after the happening of a covariate shock so as to provide empirical evidence of resilience.

This paper firstly provides an empirically-workable definition of "resilience" at household as well as individual levels. At the household level, resilience is based on the measurement of household food consumption per capita and is defined by the speed of the recovery of food consumption from a shock. At individual level, on the other hand, body weight is used for the measurement of resilience and the speed of the recovery of body weight from a shock is the definition of resilience.

Then, this paper demonstrates how to measure resilience using our own survey data collected in the Southern Province of Zambia, the most drought-prone zone in the country. Just after we started data collection in the field, unusual heavy rain took place in December 2007. Since the heavy rain damaged crops in the field and destroyed infrastructure such as road and bridge, we considered that it should have caused a shock to households and individuals in the study site. The analyses compare two sites: Site A and Site B. Normally Site A receives fewer rain and more susceptive to drought than Site B. But the heavy rain in December 2007 occurred in both sites almost equally. Nevertheless, only in Site A significant reduction of food consumption per capita and body weight was observed, and it took several months for both indicators to return to the original level. By definition, households and individuals in Site A are less resilient that those in Site B.

1. Introduction

Risks are everywhere and a part of rural life in developing countries. It is well known that rural households are practicing a variety of measures to manage risk *ex ante*, such as crop diversification and income diversification (Dercon, 2005). However, since such risk management measures are costly and imperfect, risk events such as drought often cause shocks to households, e.g. a decline of consumption. That is, shocks are almost inevitable in a risky environment. It does not necessarily mean that the impact of the shocks is significantly serious since households can mitigate the impact by taking various coping behaviors such as liquidating assets, increasing labor supply, receiving gifts, and so on (Dercon, 2002). Hence, as much as households have capacity to cope with shocks, they can mitigate their impact and as a result their consumption is smoothed. There is a volume of empirical literature that examines coping behaviors and tests consumption smoothing in rural areas of developing countries, generally demonstrating that rural households are usually able to smooth consumption in the case of idiosyncratic shocks and even in the case of covariate shocks they could smooth consumption to some extent depending on their capacity (Hoddinott and Harrower, 2005; and Dercon, Hoddinott, and Woldehanna, 2005).

However, the existing literature on consumption smoothing does not consider time that requires for households to recover the level of consumption. In order to test consumption smoothing, a panel data that contain at least two observations at different points of time are required. But since the interval between two observations is usually one year, or even several years, some shocks cannot be observed if consumption level recovers within the interval. One of obvious shortcomings of such analyses is that welfare impact of a shock can be underestimated if data collection after the risk event is conducted after the recovery or even in the process of recovery. Another problem is that such analyses cannot exactly estimate the magnitude of the shock (i.e. reduction of consumption) and the speed of recovery (i.e. time required for recovery) if recovery already starts when *ex post* data collection is conducted.

In order to improve the existing literature on consumption smoothing, this paper incorporates time dimension in the process of recovery from a shock. For this purpose, this paper adapts the concept of resilience from ecology and defines it in the context of consumption smoothing. Moreover, unlike most of previous studies on consumption smoothing, this paper utilizes weekly data collected before and after the happening of a covariate shock so as to provide empirical evidence of resilience.

2. Definitions

Gunderson et al (2002) distinguish two different ways of defining resilience in the ecological literature: one is engineering resilience and the other is ecological definition. The engineering resilience is "the speed of return to the steady state following a perturbation," conceiving ecological systems to exist close to a stable steady state. On the other hand, ecological resilience assumes multiple stability domains and is measured by "the magnitude of disturbance that can be absorbed" before instabilities shifts or flip a system into another regime of behavior. Thus, the concept of resilience can be immediately translated into economics. The concept of engineering resilience fits in economics that assumes a single stable equilibrium, while that of ecological resilience corresponds to multiple equilibria in economics. In the context of risk-coping and consumption smoothing, risk-coping implies at least short-run that a household moves back to the original state to keep consumption level unchanged or to minimize the time period where consumption level is below the normal. However, it is possible to assume a multiple equilibrium system in this context, for example the case where a household shifts its regular income source from agriculture to non-agriculture after a shock. The multiple equilibrium model seems to be more like adaptation in the long-run rather than coping in the short-run, and therefore the existing literature on risk-coping seems to implicitly assume a single equilibrium. In the second part of this paper, empirical analyses will be done using data collected weekly in the Southern Province of Zambia. Since the data covers only 6 months during one cropping season of 2007/08, the concept of engineering resilience fits better the situation. That is, resilience in this paper is "the speed of return to the steady state."

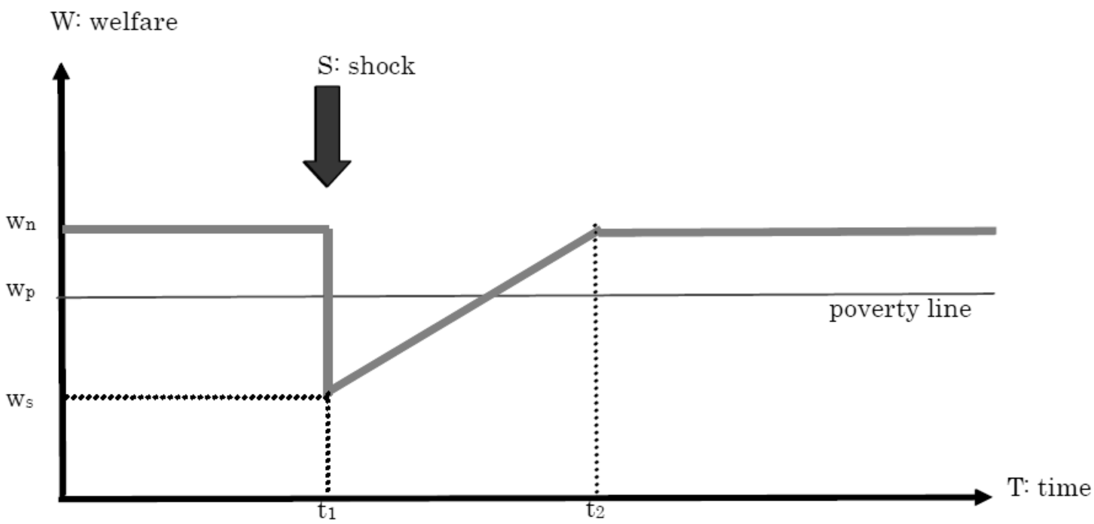

Figure 1. Schematic Definition of Resilience and Vulnerability

The definition is schematically presented in Figure 1. The vertical axis measures welfare state and the horizontal axis represents time. Figure 1 shows that welfare level at the steady state is W_n. From time 0 to time t_1 when a shock occurs, welfare level remains at the steady state level, then at time t_1 welfare level plunges from W_n to W_s due to the shock. At time t_1 welfare level starts recovering, and at time t_2 it returns to the original level, i.e. W_n. The recovery may not take place immediately after the shock; rather the lowest level of welfare may continue for a while. But the scheme is simplified. Figure 1 also indicates poverty line, which can be given at arbitrary welfare level, W_p, below which the household or the individual is considered to be poor.

Now following the definition of engineering resilience, resilience (R) can be defined in Figure 1 as below

$$R = \frac{W_n - W_s}{t_2 - t_1} = \frac{\Delta W}{\Delta t} \quad (1).$$

That is, resilience is measured as the slope of the welfare curve in Figure 1. Even if a shock occurs, if it does not affect welfare level at all (i.e. $\Delta W = 0$), resilience cannot be defined based on the definition above. However, in order to make the resilience indicator complete, R should be defined to be infinite when $\Delta W = 0$ (perfectly resilient). That is, if both $\Delta W = 0$ and $\Delta t = 0$, $R = \infty$. On the other hand, if welfare level never recovers, i.e. $\Delta t = \infty$, then $R = 0$ regardless of the magnitude of ΔW (no resilience at all).

Related indicators that are often used are vulnerability and poverty. Vulnerability (V) is an indicator how a household or an individual is sensitive to the shock concerned. Thus, the indicator requires the magnitude of the shock. If the magnitude is given by S, then vulnerability can be defined as

$$V = \frac{W_n - W_s}{S} = \frac{\Delta W}{S} \quad (2).$$

By definition, V is measured only at the time of shock, t_1. When two households are compared, if they are affected by a shock with the same magnitude, a household whose reduction of welfare is larger is more vulnerable regardless of the level of steady state welfare.

Poverty (P) is defined as the distance from the poverty line only when welfare level is below the poverty line. If welfare level is on or above the poverty line, the household is not considered to be poor, or $P = 0$. Thus, P is given by

$$\begin{aligned} P &= W_p - W \quad \text{if } W_p > W \\ &= 0 \quad\quad\quad\;\; \text{if } W_p \le W \end{aligned} \quad (3)$$

where W is welfare level at the time when poverty is to be measured. It is important to note that poverty can be measured at any point of time. In the case of Figure 1, $P = 0$ from time 0 to time t_1, $P = W_p - W_s$ at time t_1, then P is decreasing and returns to 0 at a certain point between t_1 and t_2 where $W = W_p$. After this point, P stays 0.

Note that if surveys are conducted before t_1 (i.e. before the shock) and after t_2 (i.e. after the recovery), no matter how low W_s is (or in other words, no matter how large ΔW is), $R = \infty$ (i.e. perfectly resilient), $V = 0$ (i.e. never vulnerable), and P is always 0 (i.e. never poor). This is the case of the underestimation of welfare impact of a shock, as mentioned previously. In addition, in such cases it is not possible to distinguish between "never vulnerable" (i.e. $\Delta W = 0$) and "highly resilient" (i.e. $\Delta W > 0$ but W returns to W_n before the second survey). It is important to distinguish them empirically because they should have different policy implications.

3. Empirical Strategies

In order to measure resilience based on the definition given in the previous section, welfare need to be defined and measured first. Since this paper concerns resilience at household level and individual level, welfare should be measured at those levels. In the case of household welfare, it can be measured by the real value of food consumption per capita, the calories of consumed food per capita, and the real value of total consumption per capita. In the case of individual welfare, on the other hand, anthropometric data should be used for welfare indicator such as body weight and skin-fold thickness.

Then, risk event must be specified, from which the speed of welfare recovery will be measured as resilience according to definition (1). If the risk event is covariate such as drought, heavy rain, war, economic crisis, and so on, a common time period during which the speed of recovery is measured can be introduced. But idiosyncratic risk events such as illness, death, divorce, theft, and so on can also be considered in the same framework. In such a case, time period for recovery is also household or individual specific.

The risk event in question does not necessarily cause a shock to households or individuals. Since by definition a shock is a decline of welfare level immediately after the risk event (i.e. before recovery starts), if a household or an individual is never vulnerable (i.e. $\Delta W = 0$) there is no shock in spite of the risk event.

4. Data

This paper uses the data collected as part of Resilience Project of Research Institute of Humanity and Nature. The Project's study area is in the Southern Province of Zambia, the most drought-prone zone in the country. Within the study area, three agro-ecologically-distinctive sites, namely Site A, Site B, and Site C, are selected for detailed household survey. The three sites are spread over the slope adjoining Lake Kariba: Site A is located on the lower terrace of the slope on the lakeshore; Site C is located on the upper terrace of the slope on the southern edge of Zambian plateau; and Site B is located on mid-escarpment between the two sites. Based on village census conducted before the rainy season in 2007, 16 households in each site, thus 48 households in total, were selected for household survey.

The household survey consists of three components: (i) household interview; (ii) household members' anthropometric measurement; and (iii) rainfall measurement on household's plot. Each household is interviewed conducted every week by an enumerator using structured questionnaires. Information obtained from the weekly interview is as below:

- Food and non-food consumption
- Input/output and stock of agricultural production
- Other economic activities (non-agricultural work, natural resource collection, etc.)
- Transfer received and sent
- Time use of each household member
- Health condition of each household member (self-reporting)

In addition to the weekly interview, annual and monthly interviews are also conducted to obtain household information on asset holdings and demographics. For the anthropometrics, the same enumerator measures household members' body weight, height, skin-fond thickness, and upper-middle arm circumference using special instruments at the time of interview. Plot-level rainfall is recorded every 30 minutes by a rain gauge installed on a plot of each sample household. The data collection started in November 2007 at the beginning the rainy season of 2007/08 and continued throughout the rainy season.

Unfortunately, due to technical problems in logistics, data collected in Site C is not complete, i.e. large amount of missing data in household interview. Therefore, this paper uses data from Site A and Site B only.

5. Results

5.1 Risk Event: Heavy Rain

First, risk event must be identified. Project's researchers and enumerators working in the field experienced very heavy rain in December 2007, just after data collection had started in November 2007. The heavy rainfall and associated flood damaged crops just planted in November and destroyed infrastructure such as road and bridge through which people and vehicles access to town. According to villagers, such heavy rainfall is very rare or even once a several decades in the study area, which is known as the driest in the country and drought-prone. Although we cannot know how unlikely such an event takes place in the villages we selected since there is no long-term, reliable precipitation record around the study area, based on our own observations and information given by villagers we considered that the heavy rain in December 2007 is an unexpected risk event that should have caused a shock to villagers.

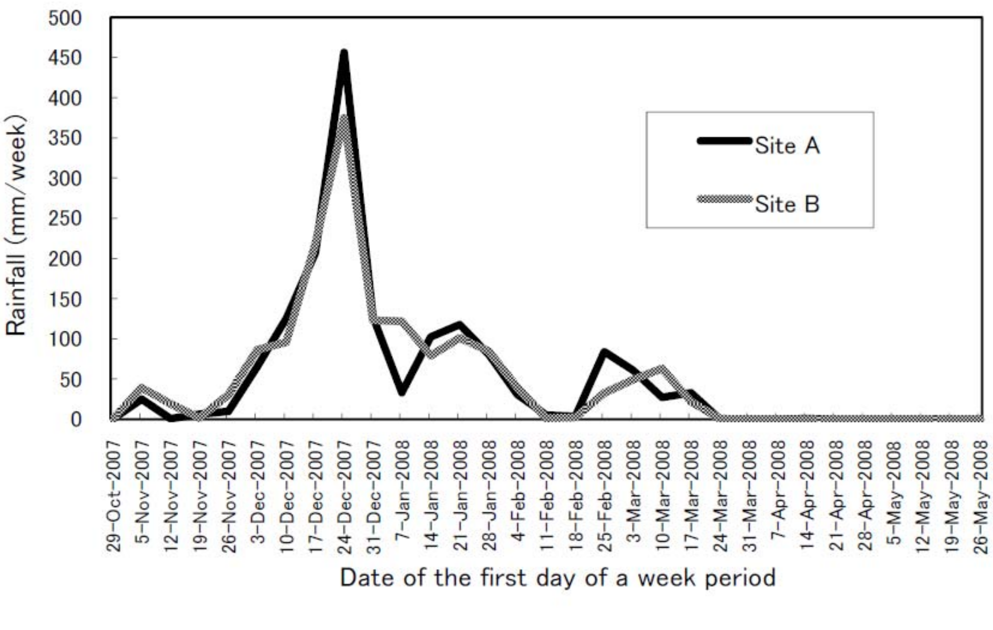

Figure 2. Weekly Precipitation in the Study Sites

Figure 2 presents weekly precipitations during the rainy season 2007/08. The weekly precipitation is obtained as the average of 16 rain gauges installed in the field of sample households in each study site. Out of 16 rain gauges, 6 rain gauges in Site A and 3 rain gauges in Site B give incomplete data due to errors, and such incomplete data are not used for calculating weekly precipitations. As shown in Figure 2, both Site A and Site B had heavy rain in December 2007, particularly during the week starting from December 24th.

Table 1. Annual Precipitation of 2007/08 Cropping Year

	Number of Rain Gauges	Mean (mm)	St. Dev. (mm)	Max. (mm)	Min. (mm)
Site A	10	1603	48	1699	1559
Site B	13	1586	59	1673	1488

Table 1 summarizes precipitation data aggregated at the annual level. It is generally believed from the experience that Site A has smaller mean and smaller spatial variation of precipitation, and hence is more frequently affected by drought. However, in 2007/08 the annual precipitations in the two study sites are very close; Site A's precipitation is even higher although the difference is statistically not significant. On the other hand, spatial variation of annual precipitation is higher in Site B than in Site A, which may reflect the hilly landscape in Site B and is as normally expected. These observations suggest that the heavy rain shock should be severer in site A than in site B.

5.2 Household Welfare Indicator: Consumption per Capita

The weekly household interviews ask about food consumed by the household members during the last week. The food includes self-produced food, purchased/gifted food, and edible items collected in the field (bush and lake).

In order to construct a welfare indicator from the food consumption data, all the food items are evaluated using market price and if market price is not available values are evaluated by respondents. Then, the value of the food consumed is aggregated at the household level for each week and the total value is divided by the adult equivalent household size; in this way food consumption per week per adult equivalent in nominal monetary term is obtained. Finally, the nominal values are deflated by the local food price index[1] to obtain food consumption per week per adult equivalent in real monetary term, which is used as the welfare indicator of household in this study.

Now in order to know the fluctuation of food consumption after the heavy rain event in the week of December 24th, the following equation is estimated for each zone separately.

[1] Based on the weekly interview on food consumption, locally-common food basket is determined first. The food basket is fixed during the survey period and common to all the study sites: The basket for 16 households per week consists of 6.1 buckets of maize, 1.8 bags of 25 kg bag of maize flour, 2.6 packets of dried small fish, 2.8 piles of dried fish. The cost for purchasing the basket is evaluated every week using their market prices. Each study site has different market prices and they fluctuate a lot during the cropping season, as a result the cost differs spatially as well as temporally. The relative cost is used as the food price index for this study, setting the cost of the first week in Site A to be 100.

$$\ln(C_{iw}) = \alpha + \beta_1 Q_{iw} + \beta_2 Q_{iw}^2 + \sum_{w\geq 8} \delta_w D_w + HH_i + \varepsilon_{iw} \quad (4)$$

where ln is the operator of natural logarithm; C_{iw} denotes household i's (i = 1, 2, . . . , 16) real value of food consumption per adult equivalent in week w (w = 1, 2, . . . , 27); Q_{iw} denotes household specific weekly rainfall recorded household i's plot in week w; D_w denotes a binary dummy variable for the week w; HH_i is household i's fixed (i.e. time-invariant) effect; α, β_1, β_2,and δ are parameters to be estimated; and ε_{iw} is the residual. The week dummies start at week 8, which corresponds to the week of December 24th. Thus, equation (4) assumes that before the heavy rain event household consumption level remains at the normal level on average and after the heavy rain event household consumption level may start fluctuating. Thus, the fluctuation of average food consumption at the study site is captured by these week dummies. On the other hand, the household fixed effect is meant to capture household fixed factors that affect consumption level such as asset holding, age and gender composition, type of occupations that may have different energy requirement, soil type and plot location that may affect agricultural productivity, and so on.

Table 2. Results of Fixed Effect Regression of Household Consumption Equation[1]

	Coefficients Estimated			Test if the weekly dummies (D_w) jointly have any effect	R squared	Number of observations (16 households by 27 weeks)[2]
	Constant (α)	Weekly Rainfall (β_1*10^3)	Weekly Rainfall Sq (β_2*10^6)			
Site A	6.80 (0.08)***	2.63 (0.78)***	-5.54 (1.42)***	Yes***	0.18	288
Site B	6.16 (0.14)***	1.40 (0.57)**	NA[3]	Yes***	0.10	294

Standard errors are in parentheses. *** and ** are indicate significance level 1% and 5% respectively.
[1] Fixed effect regression is done for Site A and Site B separately.
[2] The panel data is unbalanced due to missing data in household interviews and/or rainfall data.
[3] When both weekly rainfall and its squared term are included, neither is significant probably due to multicollinearity. But if the squared term is dropped, weekly rainfall has a significantly positive effect. The exclusion of the squared term does not change other estimates much.

The results of fixed effect estimation of equation (4) are summarized in Table 2. In Site A plot specific weekly rainfall has a significantly positive effect on the consumption during the same week, but the negative coefficient for the squared term implies that the effect becomes negative above a certain level of rainfall, which suggests the existence of heavy rainfall shock. The level where the impact becomes negative is calculated at about 48 mm/week. Based on the weekly precipitation as shown in Figure 1, heavy rainfall in December 2007 and even rainfall in January 2008 are considered to have a negative impact on household's food consumption. Note that the heavy rainfall has an immediate impact on food consumption before the time of harvest when they will realize a poor yield, which implies that the damage caused by the heavy rain created lower expectation of harvest and discouraged food consumption even before the harvest. Such a negative effect is not observed in Site B. Rather, as shown in Table 2, the coefficient estimated is positive and significantly different from zero, if the squared term of weekly rainfall is dropped. It means that the more rainfall received, the more food is consumed even before harvest in Site B.

As for the weekly dummies, after controlling for the plot specific weekly rainfall, they are jointly different from zero. Those dummies capture the deviation of village mean consumption from the normal level, thus if mean consumption fluctuates a lot after the heavy rain, the heavy rain is considered to create a covariate shock in the study site.

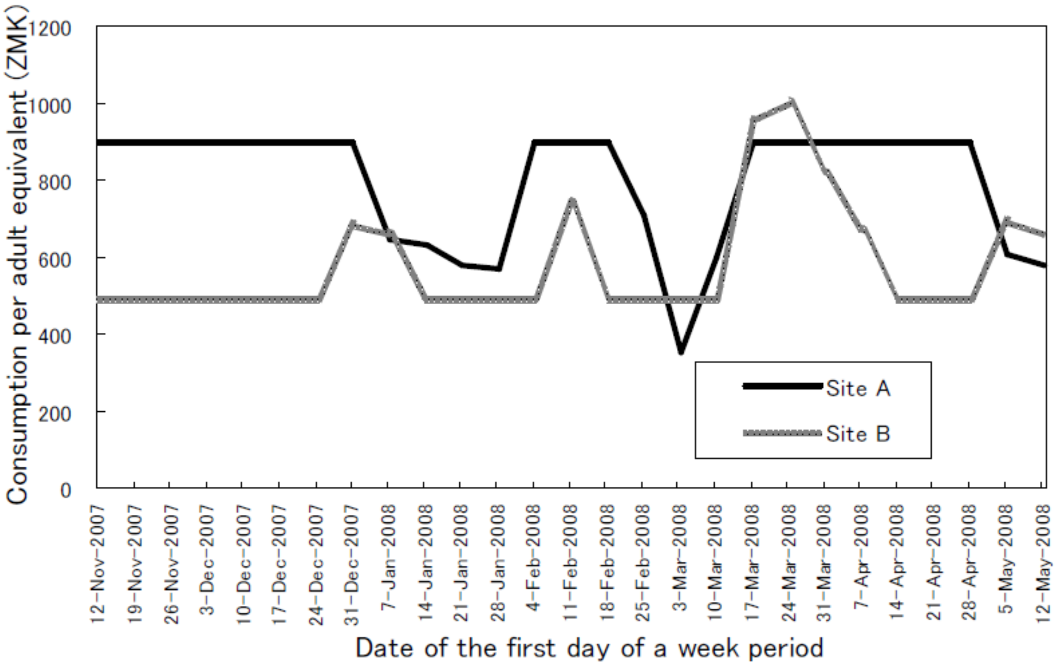

Figure 3. Deviation of Food Consumption from the Normal Level

Note: Average food consumption before the heavy rain is assumed to be the normal level of food consumption. The deviation from the normal level is obtained from the coefficients for weekly dummies specified in equation (4). If estimated coefficient is not statistically different from zero, food consumption of the week is the same as the normal level.

Figure 3 presents the fluctuation of village mean consumption. It is assumed that the mean consumption level is constant at normal level before the heavy rain during the week of December 24th (or week 8). Then, after week 8, if the coefficient of a week dummy is not significantly different from zero, consumption level is considered to be the same as before week 8, but if the coefficient of a week dummy is significantly different from zero, consumption level is adjusted based on the magnitude of the coefficient estimated. As shown in Figure 3, a negative impact of the heavy rain is observed immediately after the event in Site A, and it persists for four weeks. Then the consumption level recovers, but another small peak of rainfall again decreases consumption in February/March 2008. Consumption level becomes normal after start harvesting in March 2008. On the other hand, in Site B, there are two small rises of consumption in December 2007 and February 2008, but the reason is unknown. Then, the large peak in March 2008 should be due to harvest, particularly due to the consumption of fresh maize whose market value is very high. Therefore, the heavy rain in December 2007 has no impact on household welfare in Site B.

With respect to resilience at household level, households in Site B is more resilient than those in Site A on average since by definition Site B shows "perfect resilience." However, even households in Site A are resilient against the heavy rain shock as their welfare level seems to have recovered in a few weeks.

5.3 Individual Welfare Indicator: Body Weight

This paper uses body weight as a welfare indicator at individual level. In the household survey, body weight of all the household members available at the time of interview is measured using a portable digital scale. Then, the indicator is defined as the deviation of individual's body weight from his/her own average weight.

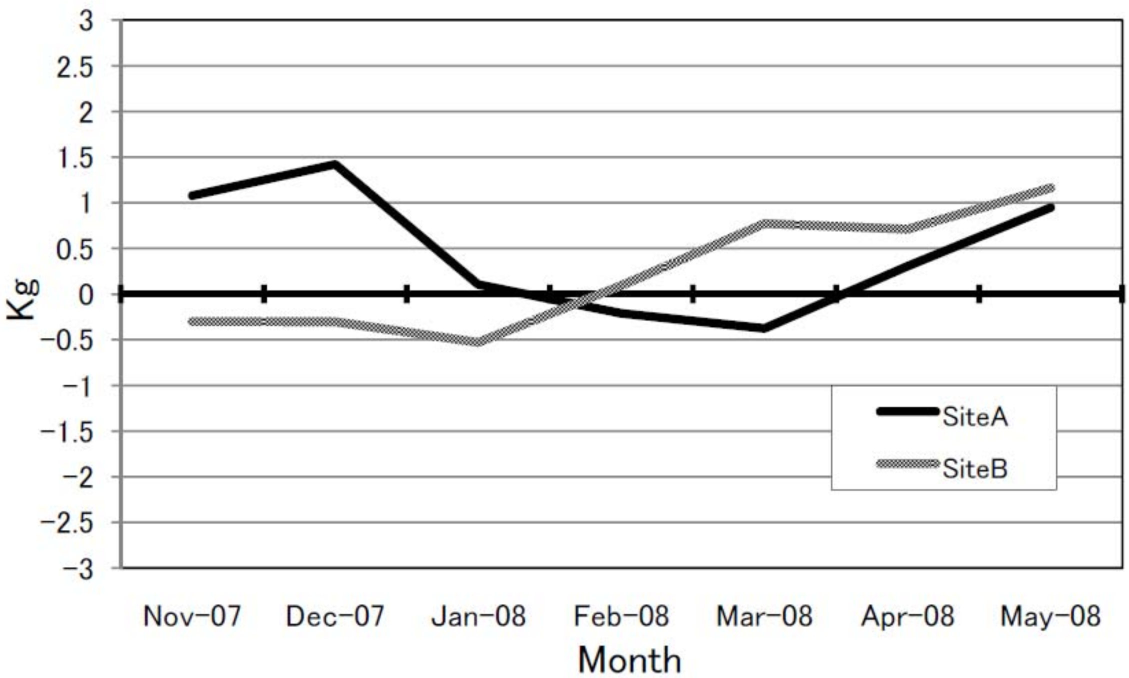

Figure 4. Deviation of Body Weight from the Average

Note: The graph shows body weight change during 2007/08 cropping season. The deviation is calculated as the difference between individual's body weight of the month and his/her annual average, both of which are obtained from weekly body weight measurements. The graph presents the mean value of deviations of 31 adults for Site A and that of 40 adults for Site B. Adults are defined as anyone whose age is 16 or above it regardless of the sex.

Figure 4 presents the trend of the welfare indicator for Site A and Site B. It is clear that adults in Site A decreased their body weight in January, February, and March 2008, then recovered in April and May 2008, which is after harvest. In Site B also a decrease of body weight is observed in January 2008, but the decline is very small compared with the case of Site A, and in February 2008 body weight started increasing, which is much earlier than in Site A. The distinctive patterns of body weight change are consistent with the food consumption presented in Figure 3.

With respect to resilience defined in equation (1), the speed of recovery in Site A (imaginary slope between January - May 2008) is much smaller than in Site B (slope between January – February 2008). Thus, by definition, Figure 4 indicates that individuals in Site B are more resilient than in Site A.

6. Conclusions

This paper firstly provides an empirically-workable definition of "resilience" at household as well as individual levels. At the household level, resilience is based on the measurement of household food consumption per capita and is defined by the speed of the recovery of food consumption from a shock. At individual level, on the other hand, body weight is used for the measurement of resilience and the speed of the recovery of body weight from a shock is the definition of resilience.

Then, this paper demonstrates how to measure resilience using our own survey data collected in the Southern Province of Zambia, the most drought-prone zone in the country. Just after we started data collection in the field, unusual heavy rain took place in December 2007. Since the heavy rain damaged crops in the field and destroyed infrastructure such as road and bridge, we considered that it should have caused a shock to households and individuals in the study site. The analyses compare two sites: Site A and Site B. Normally Site A receives fewer rain and more susceptive to drought than Site B. But the heavy rain in December 2007 occurred in both sites almost equally. Its impact, however, differs between the two sites. In Site A, an immediate decline of food consumption per capita and a gradual reduction of body weight are observed. While the consumption recovered after several weeks, it took several months for the body weight to return to the original level. In Site B, on the other hand, heavy rain does not induce such shocks. Hence, households and individuals in Site A are considered to be less resilient that those in Site B, but those in Site A still demonstrate resilience against the heavy rain shock.

In conclusion, this paper shows that the concept of resilience can be applied to the analyses of household behavior in the variable environment and that food consumption and body weight are useful welfare indicators to measure household resilience and individual resilience. Resilience obtained in such ways will be used in the future study to identify determinants of household/individual resilience such as assets, education, networks, etc. In addition, the effect of household coping behavior including *ex post* migration, off-farm labor supply, and gift-receiving on resilience will be investigated.

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Variation in the Nutritional Status of Adults Living in Contrasting Ecological Zones in the Southern Province of Zambia

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Abstract

In the previous annual report (Yamauchi, 2009), we described the nutritional status of adults and children and the growth status of children in the initial stages of a longitudinal survey of people living in three ecologically contrasting zones (Upper flat land zone, Middle slope zone and Lower flat land zone) in Southern Zambia. We demonstrated that adults living in the Lower zone were taller and heavier than their counterparts living in the other two zones (Yamauchi, 2009).

In this report, we illustrate the month-by-month variations in body weight and body mass index (BMI) by sex in the three contrasting living environments during a 16-month period. Common patterns of variation in both body weight and BMI were observed in sex-regional subgroups, which suggest that they are related to variations in the climate (precipitation) and the agricultural cycle. Furthermore, men and women had quite similar patterns of variation of both body weight and BMI. We expect that there are similar patterns of diet and physical activity between men and women living in the same environment.

Consistent with the findings of our previous report, the Lower zone men and women were heavier than their counterparts from the Middle and Upper zones, although the BMI of the Lower zone men was the lowest of the three groups because these men were taller. There were contrasting sex differences in the BMI among the three zones: the sex difference was largest in the Lower zone, moderate in the Middle zone, and slight in the Upper zone.

Further studies are needed to clarify the mechanisms of these findings; for instance, to examine the relationship in the variation of body weight and BMI with the annual climate (precipitation) variation, food production and consumption. It would also be desirable to carry out dietary surveys, behavioral observations and estimations of energy expenditure.

1. Introduction

In October 2007, we started a longitudinal survey of growth and nutritional status, monitoring local people dwelling in five villages located in the Sinazongwe district in the Southern province of Zambia, to examine the influence of decreased water and food availability caused by drought (Yamauchi et al., 2008). We have reported the nutritional status of adults and children, and the growth status of children, in the initial stages of a longitudinal survey of people living in three ecologically contrasting zones: the Upper flat land zone on the plateau, the Middle slope zone and the Lower flat land zone near Lake Kariba. Adults living in the Lower zone were taller and heavier than their counterparts living in the other two zones

(Yamauchi, 2009).

This article describes month-by-month variations in adults' nutritional status by sex and living environment (zone) during the 16-month period between November 2007 and February 2009, using weekly body weight data and calculated BMI (= body weight (kg) / height (m)^2).

2. Subjects and Methods

2.1 Study populations

The slope area around Lake Kariba can be divided into three ecological zones: the upper flat land zone on the plateau ('Upper'), the middle slope zone ('Middle') and the lower flat land zone near Lake Kariba ('Lower') (Sakurai 2008). We chose five villages, comprising two (Sianemba and Siameja) from the Lower zone, two (Chanzika and Kanego) from the Middle zone and one (Siachaya) from the Upper zone. Forty-eight households were selected, 16 from each of the three zones: 4 in Sianemba, 12 in Siameja, 8 in Chanzika, 8 in Kanego and 16 in Siachaya.

2.2 Subjects

Among the adults (≥ 18 years old) in the 48 households, those whose data had not been obtained for more than two months were excluded from the analyses. The average number of monthly datapoints obtained was 11.4 ± 3.2 (mean ± SD), ranging between 3 and 15 months. The monthly sample sizes for body weight and BMI are shown by sex and zone in Table 1. No data were obtained for any sex-regional subgroup in June 2008, for people from the 'Upper' zone in January 2008 or for women from the 'Middle' zone in October and November 2008 (Table 1).

Table 1. Sample numbers for body weight and BMI in each month Nov 2007–Feb 2009 by sex and zone

Body weight

	2007		2008												2009	
	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
Men																
Lower	9	11	10	11	8	8	7	0	4	4	8	9	9	11	11	8
Middle	6	10	12	12	14	17	17	0	17	18	18	15	20	20	19	17
Upper	8	9	0	10	14	14	13	0	13	14	14	14	14	14	13	12
All	23	30	22	33	36	39	37	0	34	36	40	38	43	45	43	37
Women																
Lower	13	20	21	21	19	18	20	0	14	12	16	20	22	21	20	20
Middle	16	19	17	17	20	21	21	0	20	19	20	0	0	19	21	18
Upper	17	19	0	17	23	24	20	0	21	23	23	23	21	21	22	18
All	46	58	38	55	62	63	61	0	55	54	59	43	43	61	63	56

BMI

	2007		2008												2009	
	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
Men																
Lower	8	10	10	10	8	9	8	0	5	5	9	10	10	11	11	9
Middle	7	11	13	13	15	18	18	0	18	19	19	16	21	21	20	18
Upper	9	10	0	11	15	15	14	0	14	15	15	15	15	15	14	13
All	24	31	23	34	38	42	40	0	37	39	43	41	46	47	45	40
Women																
Lower	14	21	22	22	20	19	21	0	15	13	17	21	23	22	21	21
Middle	17	20	18	18	21	22	22	0	21	20	19	0	0	19	20	18
Upper	19	19	0	17	24	23	20	0	22	22	23	23	22	21	23	19
All	50	60	40	57	65	64	63	0	58	55	59	44	45	62	64	58

2.3 Anthropometric measurements

The details of the anthropometric measurements are given elsewhere (Yamauchi et al., 2008). Briefly, height was measured to the nearest 1 mm using a portable stadiometer (SECA 214, Germany). Height was measured monthly; however, the initial values were used for analysis (Yamauchi, 2009). Body weight was measured weekly to the nearest 0.1 kg using battery-operated digital scales (Tanita HD-654, Japan). Weekly body weight was averaged over each month. BMI was calculated using the height (constant) and the body weight (monthly average) for each subject. The subjects' nutritional status was defined based on their BMI as ‘underweight’ (BMI < 18.5), ‘normal’ ($18.5 \leq$ BMI ≤ 25.0) or ‘overweight’ (BMI > 25.0) (World Health Organization, 2000).

2.4 Statistical analyses

Regional differences in height, body weight and BMI were evaluated with analysis of variance with multiple comparisons (Tukey HSD test). All analyses were conducted with the JMP statistical package (SAS Institute, Cary, NC, USA) with statistical significance assigned at $P < 0.05$.

3. Results and Discussion

3.1. Overall nutritional status by sex and zone during the 16 months

The initial values for height and the monthly averaged body weight and BMI during the 16-month period are shown in Table 2. The mean BMI values for all sex-zone subgroups were within the normal range (18.5 ≤ BMI ≤ 25.0), suggesting that the nutritional status of the subjects was generally good.

According to multiple comparison analysis, the Lower zone men and women were significantly taller than the Middle zone men and women, respectively ($P < 0.05$). A similar tendency was found for body weight and women's BMI, while the opposite trend was observed for men's BMI. The Lower zone men had a significantly lower BMI than the other two groups, which was because they were significantly taller than the men in the other zones (Table 2).

Table 2. Initial height and monthly averaged body weight and BMI during the 16-month period (mean, SD and CV*)

	Height (cm)		Body weight (kg; mean over 16-mo period)				BMI (mean over 16-mo period)			
	N[1]	Mean	N[2]	Mean	SD	CV (%)	N[2]	Mean	SD	CV (%)
Men										
Lower	12	172.7	15	58.7	1.6	2.8	15	20.0	0.8	3.9
Middle	21	165.9	15	56.2	1.0	1.9	15	20.2	0.4	2.1
Upper	14	166.4	14	56.8	0.9	1.5	14	20.5	0.3	1.5
ANOVA		$P < 0.05$		$P < 0.0001$				$P < 0.0001$		
Women										
Lower	22	159.6	15	54.0	1.2	2.2	15	21.6	0.5	2.4
Middle	21	157.6	13	51.6	1.0	1.8	13	21.0	0.3	1.7
Upper	24	155.7	13	50.7	1.0	2.0	13	20.7	0.4	1.8
ANOVA		$P < 0.05$		$P < 0.01$				$P < 0.01$		

*Coefficient of variation.
[1]Number of subjects measured.
[2]Average number of monthly datapoints.

3.2. Month-by-month variation in body weight: 1) raw values

Variations in body weight are shown by sex and zone in Fig. 1. Subjects in the Lower zone were heavier than those in the other two zones, for both sexes, throughout the 16-month period. In contrast, the variation was similar between the Middle and Upper zones, for both sexes.

Overall, the variations in body weight were classified into three periods: 1) the body weight for the Lower zone men and women tended to decrease from November 2007 to March 2007, while that for both the Middle and Upper zone groups tended to increase during the same period (Fig. 1). 2) From March 2007, the body weight of all the sex-zone subgroups tended to increase until June 2008 for which there were no data. 3) Body weight tended to decrease from July 2008 to the end of the study (February 2009).

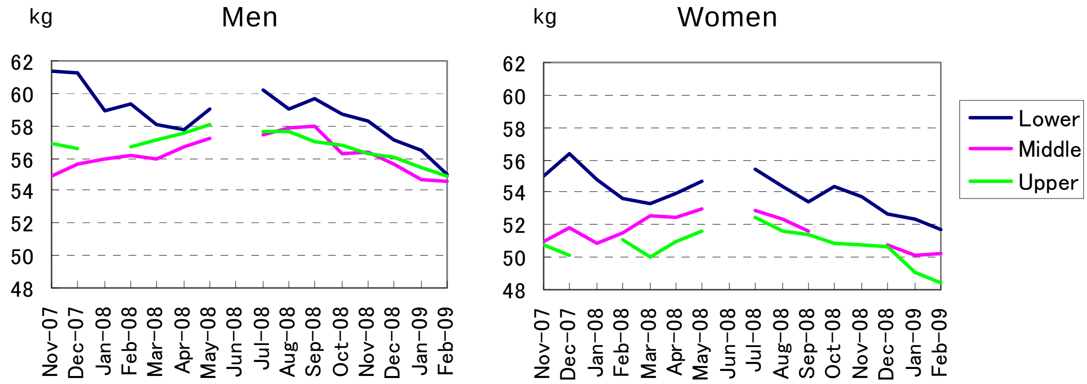

Fig. 1. Month-by-month variations in body weight by zone

Sex differences are illustrated by zone in Fig. 2. The pattern of variation in body weight was similar between men and women for all zones, although men were heavier than women by 4–6 kg throughout the 16-month period. The results imply that dietary intake and physical activity were similar between men and women in each zone.

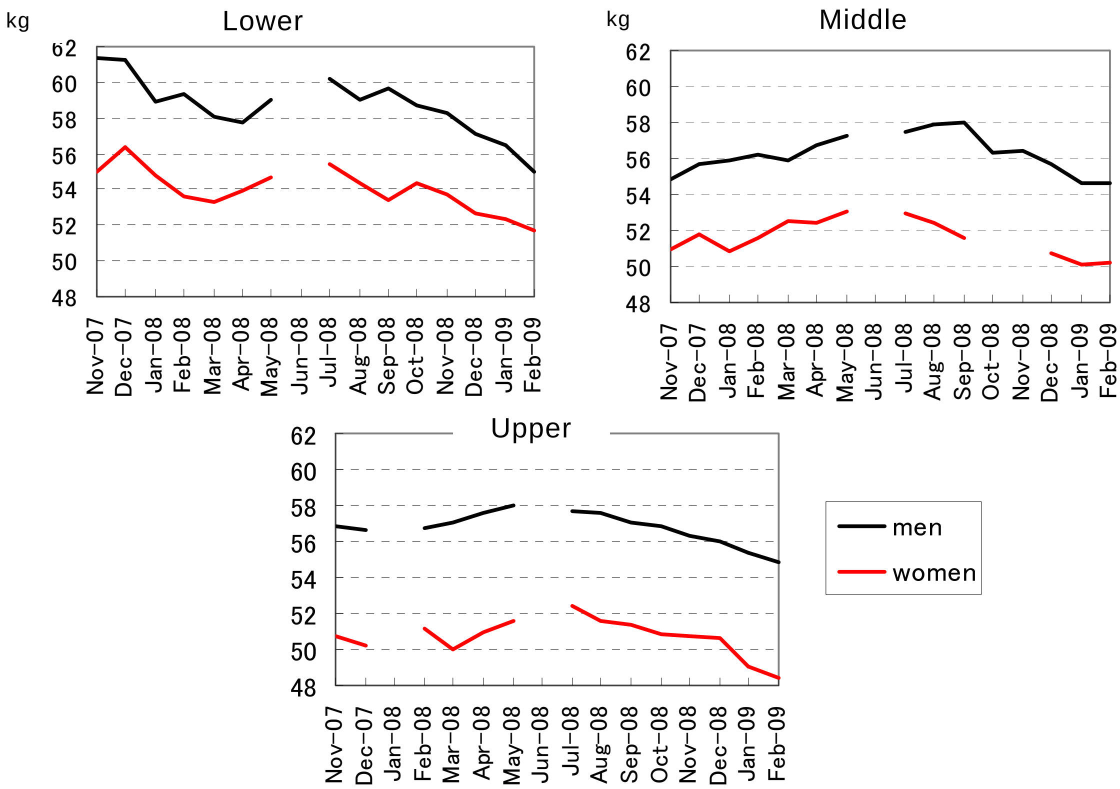

Fig. 2. Month-by-month variations in body weight for men and women in the three zones

3.3. Month-by-month variation in body weight: 2) adjusted by mean

Further analyses on the variation in body weight were conducted by adjusting body weight by the mean values during the 16-month period (Fig. 3). Throughout the 16 months, the adjusted body weight varied from the mean between +1–2 and –2 kg. The pattern of body weight variation was consistent for both sexes and across all zones: 1) decreasing (Nov 2007–Jan 2008), 2) increasing (Jan 2008–May 2008) and 3) decreasing (Jul 2008–Feb 2009). This may reflect climatic variation (especially precipitation), the agricultural cycle and variations in food production and consumption.

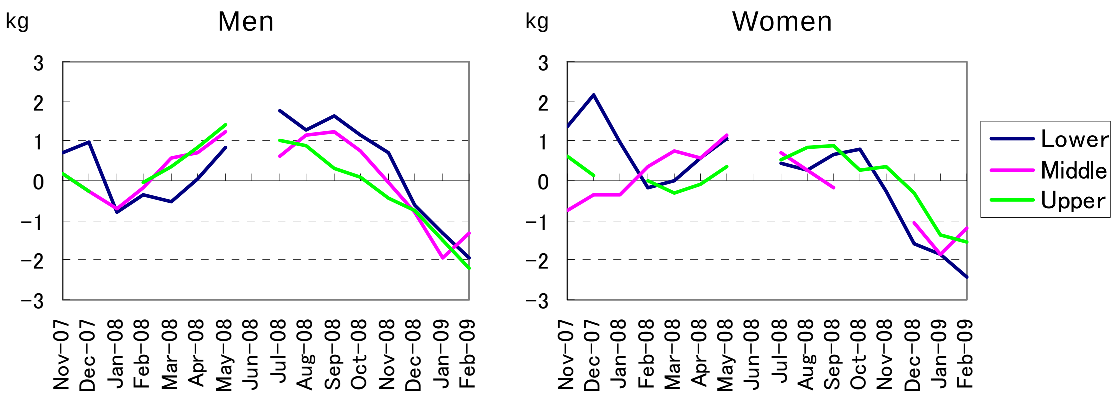

Fig. 3 Month-by-month variations in body weight (adjusted by mean)

3.4. Month-by-month variations in the BMI (raw values)

Variations in the BMI during the 16-month period are shown by sex and zone in Fig. 4. The patterns of variation in BMI were similar to those observed for body weight. Throughout the observation period, the values ranged between 18.5 and 25.0, indicating that the subjects maintained a good nutritional status for the 16 months.

When the three zones were compared, the BMI for the Lower zone men was different from that for men in the other two groups. First, similar to the adjusted body weight for the Lower zone women (Fig. 3), the BMI for the Lower zone men behaved differently from that for the other two groups in the initial three-month period. Second, a rapid drop was observed in Aug 2008. The body weight data showed a similar but much milder drop in Aug 2008 (Figs. 1 and 2), suggesting that the small decrease in body weight reflected the steeper drop in the BMI. In addition, the small sample size at this time (n = 5; Table 1) might have skewed the results. In contrast, for women, the trends in BMI variation were much more similar among the three zones, although the BMI of the Lower zone women tended to be higher than that in the other two zones in the first three-month period.

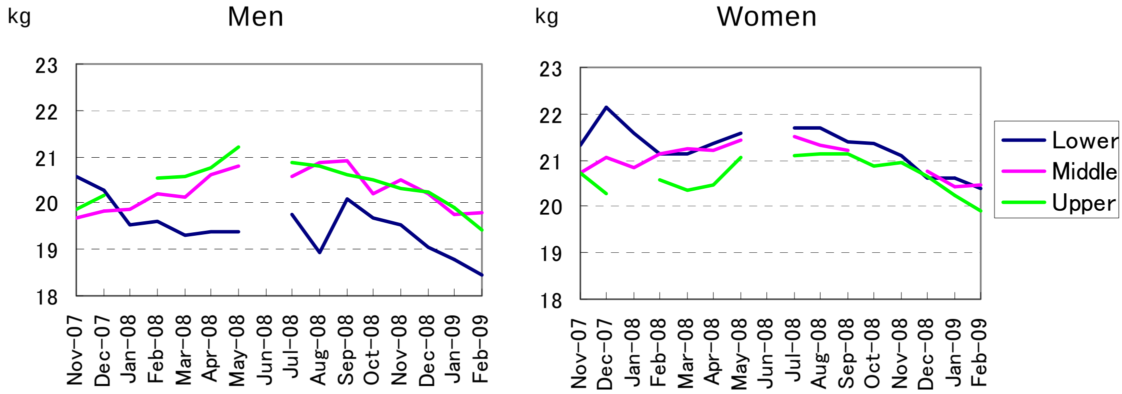

Fig. 4 Month-by-month variations in BMI

Sex differences in BMI variation are illustrated by zone in Fig. 5. Similar to body weight (Fig. 2), the BMI varied in parallel between men and women. However, in contrast to body weight, women had generally higher values than men did. The extent of the sex difference differed between the three zones: a large difference was observed in the Lower zone, there was a moderate difference in the Middle zone and a slight difference in the Upper zone. Such sex differences in BMI according to the living environment are interesting. One explanation may be the gender difference in the division of labor among the three zones. In addition, the difference in food availability and gender distribution of food might reflect the sex differences in the BMI. Further studies are needed to clarify the mechanisms causing the sex differences in the BMI.

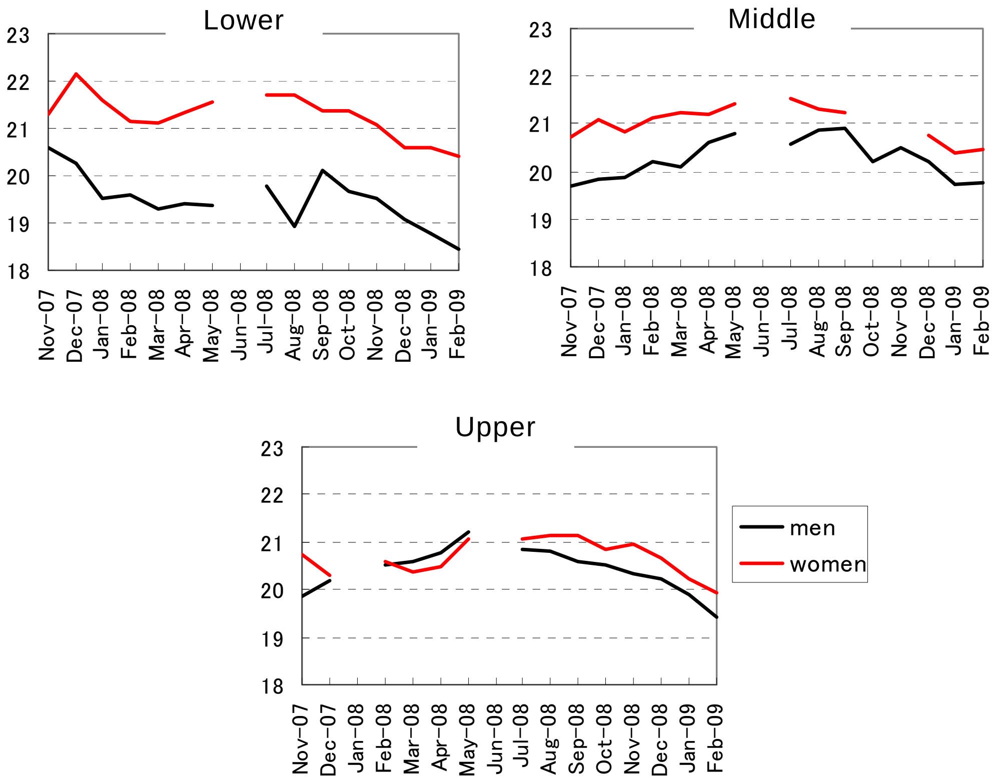

Fig. 5 Month-by-month variations in BMI for men and women by zone

4. Summary and Future Perspective

We examined variations in body weight and BMI by sex in three contrasting living environments during a 16-month period. We showed that: 1) variations in body weight and BMI were common, and were independent of either sex or location; 2) men and women had similar patterns in the variation of both body weight and BMI; 3) consistent with the findings of our previous report, Lower zone men and women were heavier than their counterparts from the Middle and Upper zones, although the BMI of the Lower zone men was the lowest among the three groups because these men were taller; and 4) contrasting sex differences in the BMI were observed among the three zones: there was a larger sex difference in the Lower zone, a moderate one in the Middle zone and a small difference in the Upper zone.

Further studies are needed to examine the relationship between the variation in body weight and BMI with annual climate (precipitation) variation, food production and consumption. It would be desirable to carry out dietary surveys, behavioral observations and estimations of energy expenditure.

In this report, we focused on the sex and regional differences in the month-by-month variation of body weight and BMI. If individual data were used, it would be possible to analyze at the household level, which would be expected to clarify strategies for households to adapt to climate change and maintain food security. Finally, it must be noted that it is important to support and re-train enumerators to encourage participation and enhance the quality and quantity of the data.

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Analysis of Meteorological Measurements Made over the 2008/2009 Rainy Season in Sinazongwe District, Zambia

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1. Introduction: Meteorological observation in 2008/2009

Local meteorological observations have been made in the Sinazongwe District, Zambia, from September 2007. A detailed analysis and results from the 2007/08 rainy season were reported in Kanno and Saeki (2009). In this paper, we summarize the characteristics of the 2008/09 rainy season and compare to the 2007/08 rainy season.

Two meteorological observation stations (weather stations) were installed at Siachaya Village (site C; high elevation, 1090 m) and Sianemba Village (site A; low elevation, 515 m). The stations were powered by a solar-charged battery and installed in a wide open area devoid of vegetation in the center of each village. Observations began in mid November 2008. Meteorological observations of air temperature, air pressure, relative humidity, solar radiation, precipitation, wind direction and wind speed were made at 30-min intervals and stored by a data logger. Wind direction was recorded as instantaneous values, whilst the other meteorological elements were recorded as mean values over a 30-min period (the 30 min prior to the time of data logging). Equivalent potential temperature (θe) and absolute humidity were calculated from air temperature, relative humidity and air pressure.

Separate to the observation stations mentioned above, a total of 48 rain gauges were installed at sites A and C as well as an additional location in Kanego and Chanzika villages (Site B; mid elevation, 720-986m) with 16 gauges at each site. Precipitation data was recorded at 30 min intervals and automatically stored in the data logger, from this data we have calculated hourly and daily precipitation means.

In this season, the condition of the rain gauges was generally poor, especially at site A. Some data loggers were broken by water overflow and other data loggers recorded zero at a period after the middle of rainy season (the cause being the rain gauge's water hole being clogged by mud). Consequently, the number of rain gauges with data which we can use was; 4 at site A, 6 at site B, and 9 at site C. At each station three rain gauges that did not experience any problems were used to form the mean precipitation data as outlined above.

2. Temporal variation of precipitation at each site

Precipitation data (recorded by the weather stations) for the two rainy seasons, 2007/08 and 2008/09, were compared for sites A and C. Figure 1 shows the accumulated daily precipitation at the two weather stations. At site A differences between the 2007/08 and 2008-09 rainy seasons were large; the total rainfall for the 2007/08 season was 1400 mm compared to 1053 mm in 2008/09, giving a difference of 247 mm. On the other hand, site C shows a small difference of 28 mm between the two rainy seasons (total rainfall at site C was 1272 mm in the 2007/08 rainy season and 1244 mm in 2008/09). This indicates that the precipitation in the high land (site C) is stable, but in the low-land (site A) precipitation tends to have a large year to year variation.

At site A the total amount of precipitation from November 1 to April 30 for the 2007/08 rainy season was 1575 mm compared to 1334 mm for the 2008/09 season (data from the separate rain gauge measurements). The rate of increase was almost constant in the 2008/09 rainy season (as shown by fig. 2), however an abrupt rise in the rate of increase (caused by heavy rain around late December) was seen in December for the 2007/08 season. The difference between the two rainy seasons was 241 mm, which is comparable to that derived from the weather station data (Fig. 1).

The total amount of precipitation at site B was 1586 mm in the 2007/08 rainy season compared to 1399 mm in 2008/09 (Fig. 3). Variations over time for both rainy seasons were similar to those from site A; the difference between the seasons is 197 mm, a little lower than at site A.

At site C the total amount of precipitation was 1401 mm in the 2007/08 rainy season compared to 1363 mm in the 2008/09 season (Fig. 4). The difference between the two rainy seasons was 38 mm, the smallest difference over the three sites.

When looking at the hourly precipitation (Fig. 5) distinct diurnal variations are present, with high precipitation between 2300 and 0100 hours at all sites (excluding the 2007/08 season at site B). At site C, a distinct diurnal variation was not clearly present for the 2007/08 season. The difference between the two rainy seasons was found to occur around the afternoon time; that is, in 2007/08 precipitation of around 50 mm/hour was observed from 1200 to 1700 hours, but in 2008/09 precipitation was low during that same period. It seems that the difference in total precipitation between the two rainy seasons was produced by heavy afternoon rainfall in the 2007/08 season. Since rainfall in the afternoon is frequently induced by unstable stratification, the difference in air stratification between two the rainy seasons might be an important factor in producing the different precipitation patterns seen here.

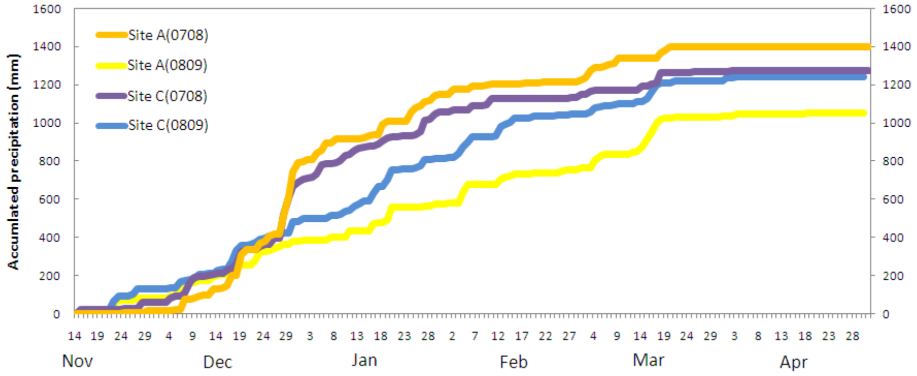

Fig.1: Daily accumulated precipitation (mm) at sites A and C from November 14 to April 30 for the two rainy seasons (2007/08 and 2008/09). Data were observed by meteorological weather stations.

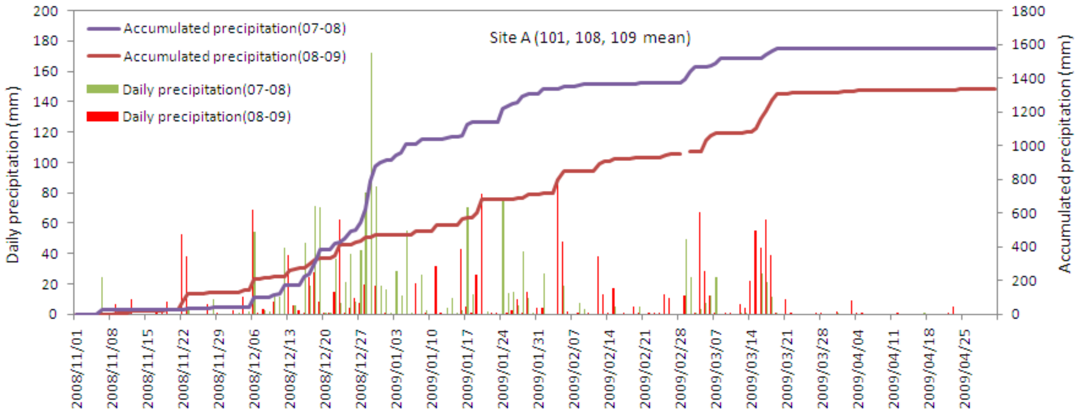

Fig. 2: Daily mean and accumulated precipitation (mm) at site A from November 1 to April 30 for the two rainy seasons (2007/08 and 2008/09). Precipitation was averaged over 3 data points for each station.

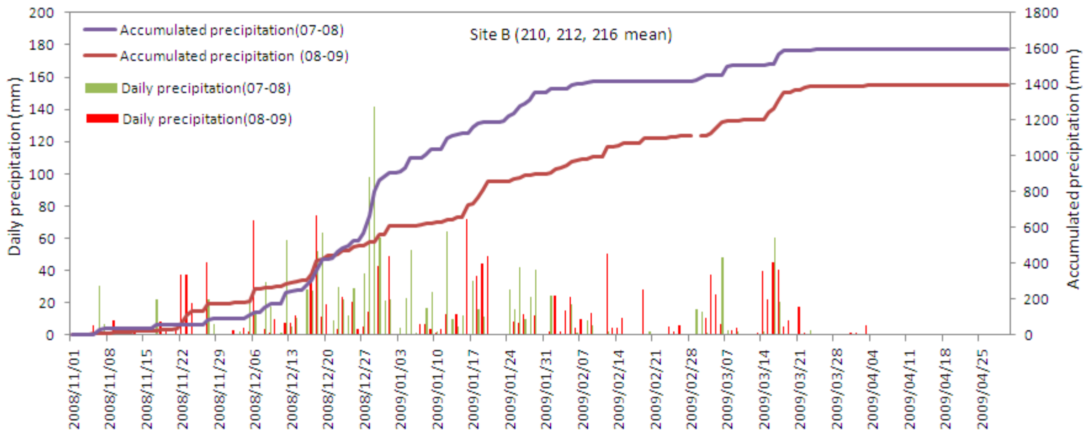

Fig. 3: As in Fig. 2 except for site B.

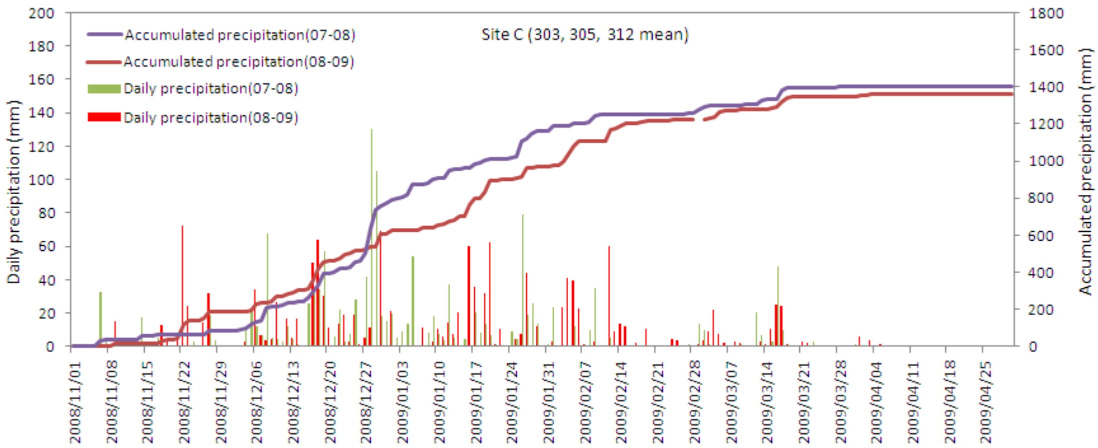

Fig. 4: As in Fig. 2 except for site C.

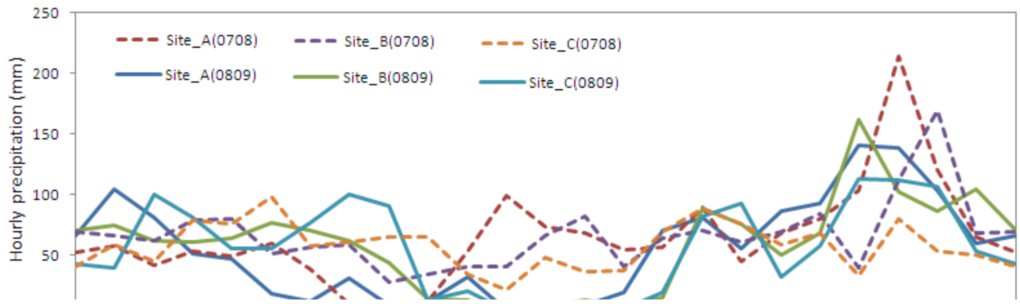

Fig. 5: Hourly precipitation (mm) from November 1 to April 30 for the two rainy seasons (2007/08 and 2008/09) at sites A, B and C.

3. Meteorological observation station data

In this section, daily and hourly variations of the meteorological parameters other than precipitation at sites A and C are discussed.

1) Temperature

At site C, during the 2008/09 rainy season from November to March, the daily mean temperature was around 20-23 °C and the daily temperature range was around 5-10 °C (Fig. 6). From the end of the rainy season in March minimum temperatures began to drop, the daily temperature range increased simultaneously. The maximum temperature stayed over 25 °C until June at which time it then dropped, sometimes lower than 20 °C, until the end of July. At site A, the temporal variations in temperature were similar but with values about 3 °C higher than at site C (Fig.7). The maximum temperature occasionally reached around 35 °C in the beginning of the rainy season and again in September.

Figure 8 shows the lapse rate of daily mean temperatures between sites C and A. The temperature lapse rate was calculated by using the height difference between the sites (1090 m at site C minus 515 m at site A = 575 m). In the 2008/09 rainy season the lapse rate was around 0.6 °C, after the rainy season the lapse rate decreased to around 0.5 °C or lower. This is lower than the moist adiabatic lapse rate (0.5 °C), implying that after the rainy season stratification may be stable. In comparison, the lapse rate for the 2007/08 rainy season was around 0.8 °C, larger than that for the 2008/09 season. This suggests that in the 2007/08 rainy season stratification might have produced unstable conditions through the rainy season and may possibly have given rise to the larger amount of precipitation than in 2008/09.

2) Wind speed

Both the 2007/08 and 2008/09 seasons show increased wind speed at site C in the early rainy season (Fig. 9). Wind speed then stabilized to around 1.0-1.5 m/s during the main period of the rainy season (December to March). By contrast, wind speed was weak (lower than 1.0 m/s) from December to March at site A in 2008/09. Looking at the variations over time between the two rainy seasons, site C shows a similar variation between the two years but there is a difference at site A. Given this difference in wind speeds and the fact that the amount of precipitation at site A varied between the two rainy seasons, it is possible that the synoptic conditions were also different.

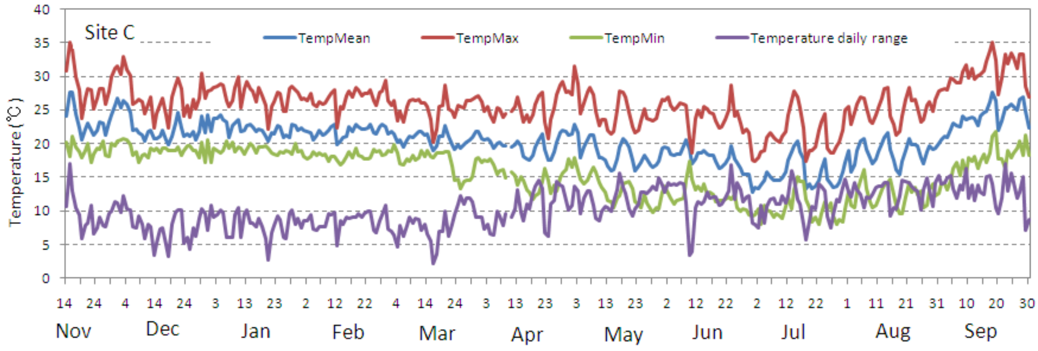

Fig. 6: Time series of maximum, average and minimum temperatures (°C) and the daily temperature range at site C from November 14 2008 to September 30 2009.

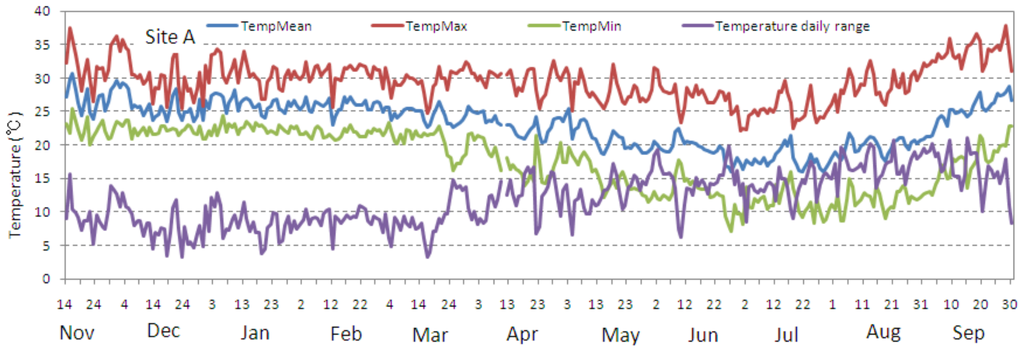

Fig. 7: As in Fig. 6 except for site A.

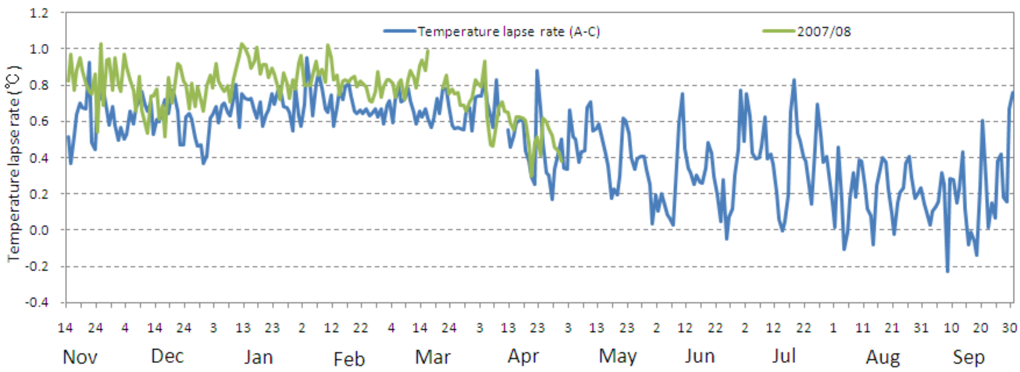

Fig. 8: Daily mean temperature lapse rate (°C/100 m) between sites A and C for the two seasons (2007/08 and 2008/09).

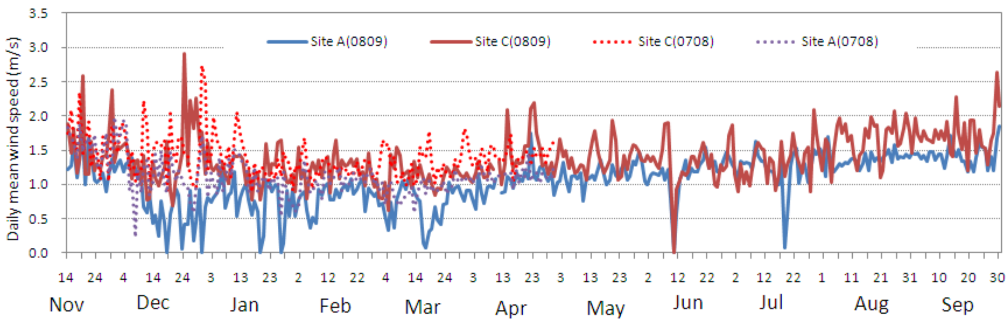

Fig. 9: Daily mean wind speed (ms^{-1}) at sites A and C for two seasons (2007/08 and 2008/09).

3) Solar radiation

The variation in daily solar radiation over time between the two sites was similar from rainy to dry seasons, but in the rainy season some differences between 2007/08 and 2008/09 were found (Fig. 10). Around late December to early January, the difference between the two rainy seasons is distinct; in 2007/08 solar radiation dropped to around 10-15 MJ/day, but in 2008/09 the value reached approximately 30 MJ/day. Since in this period precipitation also showed a difference between the two rainy seasons, it might be that a distinct synoptic system stagnated over the study area and produced heavy rainfall in the 2007/08 rainy season. On the other hand, around March, the two sites show similar variations over time for the two years, this possibly indicates that the frontal zone had moved from south to north by this time and that this occurrence may be fixed to this time every year.

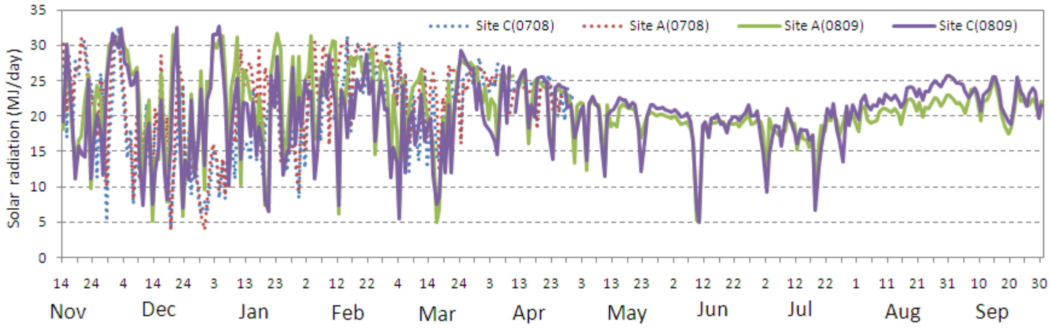

Fig. 10: Time series of daily solar radiation (MJ) at sites A and C for two seasons (2007/08 and 2008/09).

4) Humidity

For both sites A and C, during the 2008/09 rainy season, relative humidity was about 80-90% and then around late March it abruptly dropped (Fig. 11). This implies that the air mass alternated around this time. After this change, humidity gradually decreased until the dry season (around September) when it reached the least value of around 30-40%.

The mixing ratio was larger at site A than at site C (Fig. 12) due to the elevation difference. During the rainy season, the mixing ratio was around 15-20 g kg^{-1} but then dropped abruptly around late March. Since the continuous rainfall simultaneously ended at this time and the solar radiation rose (Fig. 10), it is clear that the air masses changed and was accompanied by frontal zone movement.

5) Equivalent potential temperature

The equivalent potential temperature (θe) shows a similar seasonal change to that of the mixing ratio (Fig. 13). Since θe gives a good indication of the air-mass characteristics and stratification taking into account the moisture content of the air, the difference between site A and C is also shown in Fig.13 (green line). During the rainy season, the difference was positive but from after April onward the difference varied from zero to negative, thus implying that the stratification in the rainy season was unstable and that after the last rainfall of the rainy season it maintained a stable condition.

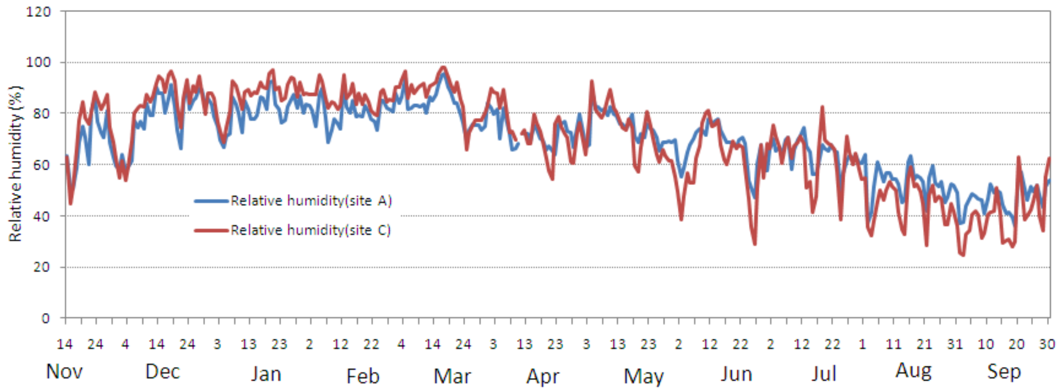

Fig. 11: Time series of relative humidity (%) at sites A and C from November 14 2008 to September 30 2009.

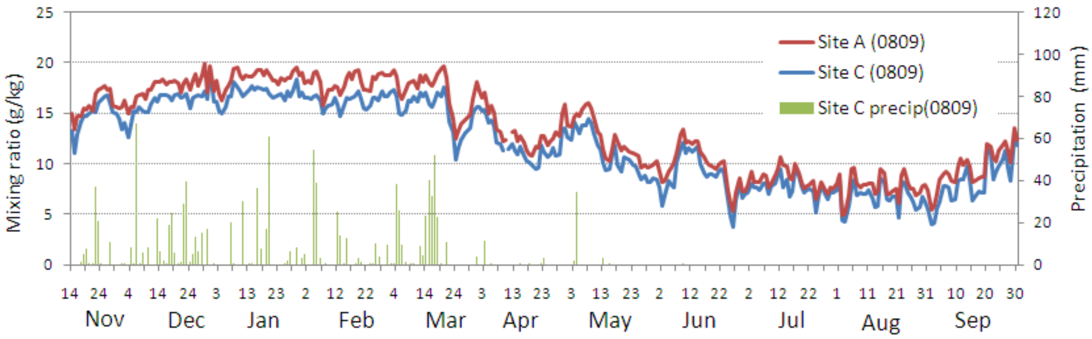

Fig. 12: Time series of mixing ratio (g kg^{-1}) at sites A and C, and daily precipitation at site C from November 14 2008 to September 30 2009.

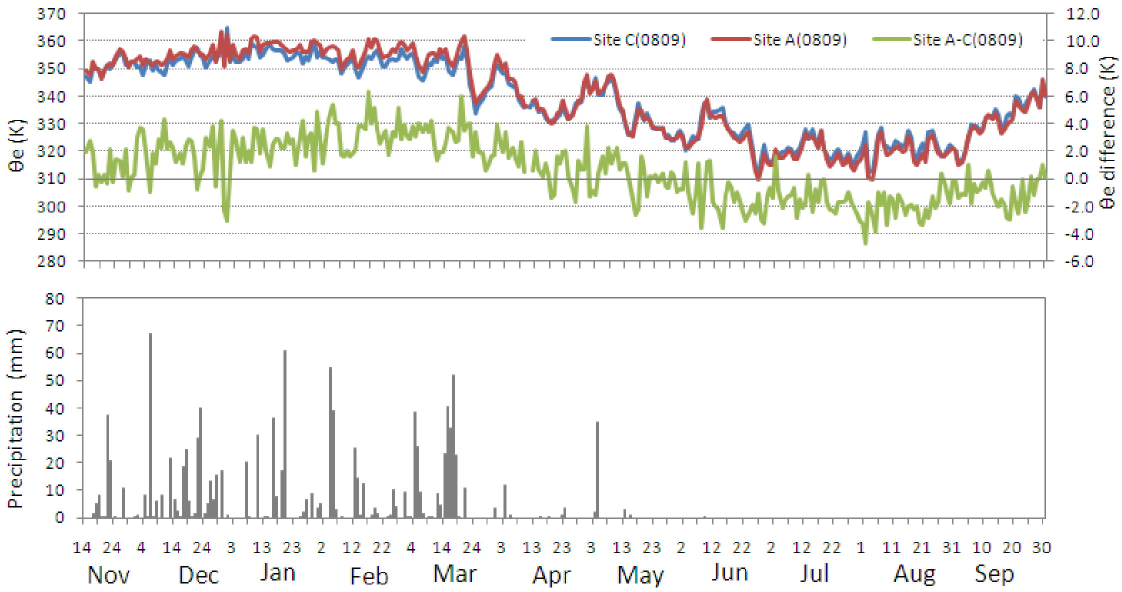

Fig. 13: Time series of equivalent potential temperature θe (K), the difference in equivalent potential temperature θe between sites A and C (as shown by green line) and daily precipitation at site C from November 14 2008 to September 30 2009.

4. Conclusions

Local meteorological observations were made at three research sites in the Sinazongwe District, Zambia from September 2007 onward. The observation data were analyzed and compared over two rainy seasons, 2007/08 and 2008/09. The results are summarized as follows:

1. Amounts of precipitation over the two rainy seasons, 2007/08 and 2008/09, show that the differences between the two rainy seasons were large at site A but small at site C. This indicates that the precipitation in the high land (site C) is stable, but tends to have a large year to year variation in the low-land (site A).

2. Hourly accumulated precipitation showed distinct diurnal variations with high precipitation between 2300 and 0100 hours at all sites (excluding the 2007/08 rainy season at site B). Since the difference between the two rainy seasons was found to occur around the afternoon time, it seems that the difference in the total amount of precipitation between the two rainy seasons was produced by the heavy afternoon rainfall in the 2007/08 season.

3. Temporal variations in temperature at sites A and C show a similar pattern, however at site A the values were higher than at site C. The lapse rate of daily mean temperatures between sites A and C showed that the lapse rate in the 2007/08 rainy season was larger than in the 2008/09 season. This suggests that throughout the 2007/08 rainy season, stratification was unstable and possibly induced the larger amount of precipitation in comparison to 2008/09.

4. Wind speed differences between the two rainy seasons were large at site A but small at site C. Given this difference and that the precipitation amount at site A varied between the two rainy seasons, it is possible that synoptic conditions were also different.

5. The daily solar radiation around late December to early January indicates a large difference between the two rainy seasons. Since in this period precipitation was also different, it may be that a distinct synoptic system stagnated and produced heavy rainfall in the 2007/08 rainy season. Also, around March for both seasons there are similar variations in solar radiation, this possibly indicates that the frontal zone had moved from south to north by this time and that this is a yearly occurrence.

6. The relative and absolute humidity might indicate that the air masses alternated and were accompanied by frontal zone movement around late March. The temporal variation of equivalent potential temperature (θe) implies that the stratification in the rainy season was unstable and that after the last continuous rainfall a stable condition was maintained.

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Effect of Sowing Date on Maize Productivity in Southern Zambia in the 2008/2009 Growing Season

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Abstract

Maize productivity in Zambia is likely to be affected by future climatic changes. To examine the factors responsible for yield variation in maize (*Zea mays* L.) near three villages at different altitudes in Zambia's Southern Province (site A = lowest, B = intermediate, C = highest), we grew maize at three different sowing dates, separated by 10-day intervals, during the 2008/2009 season. Grain yield of the control plants (normal sowing date) was higher at sites A and B (more than 1000 kg ha^{-1}) than at site C (less than 200 kg ha^{-1}). Delayed sowing did not affect grain yield at site A, but greatly reduced grain yield at sites B and C. The duration of the period from sowing to flowering at site A was not affected by the delayed sowing, but the duration increased at sites B and C by 10 to 27 days as a result of the delayed sowing. Lower air temperatures at sites B and C might explain the negative effects of the delayed sowing.

1. Introduction

Maize (*Zea mays* L.) is major food source in southern Africa, including Zambia, but its productivity is low compared to yields obtained elsewhere in the world; the mean yield in Zambia (1742 kg ha^{-1}; 10-year average from 1999 to 2008) is only 37% of the world average (4671 kg ha^{-1}), and the coefficient of variation in Zambia is roughly twice that in other countries (FAO, 2010). A slight decline in maize productivity can have detrimental effects on the lives of local farmers and their families, jeopardizing both their health and their lives. Stabilization of maize productivity in Zambia is therefore essential, particularly given current prospects for future climate change (IPCC, 2007).

The precipitation pattern is one of the most critical factors that affects maize production in southern Africa (Cane *et al.*, 1994; Phillips *et al.*, 1998), where precipitation occurs primarily during the wet season. Choosing the appropriate sowing date is therefore essential for increasing crop productivity by taking advantage of the available climatic resources under conditions in which farmers have no access to inputs such as synthetic fertilizers or pesticides. Farmers in Zambia's Southern Province have learned from experience to plant maize a few days after the second rainfall of the year, which is judged to represent the start of the wet season. However, there has been no scientific validation that this is the optimal sowing date to maximize yield.

In the present study, we examined the effects of sowing date on maize productivity at three different altitudes that differ in the amount and pattern of the precipitation they receive.

2. Materials and Methods

A local maize cultivar (‘Jileile’) was sown near villages at three different altitudes: A = Sianemba and Siameja villages (17°05’S, 27°30’E, 517 m in altitude), B = Chanzika village (17°05’S, 27°20’E, 769 m in altitude), and C = Siachaya village (16°59’S, 27°20’E, 1075 m in altitude). Sowing was conducted on three sowing dates (at 10-d intervals), at a density of 33.3×10^3 plants ha^{-1} (1 m between rows × 0.3 m between plants; sowing two to three seeds per spot; the plants were thinned after emergence, leaving only a single plant) from late November to early December in 2008 (Table 1). We chose one to three fields per village (A = two farmers, B = one farmer, C = three farmers). We defined the normal sowing date in this region as the control, then chose sowing dates 10 or 20 days later as the delayed sowing treatments. The plot size in the control treatment was 20 × 20 m, whereas those in the 10-d-later or 20-d-later plots were about 10 × 20 m. No fertilizer, herbicide, or pesticide were applied in any field.

We recorded the emergence and flowering dates in each plot. At harvesting time (in early April), maize yield was determined for the whole control plot (divided into 12 subplots), but we used four subplots (2 × 2 m) at each site in the 10-d-later or 20-d-later plots. The yield was expressed as the oven-dried (70°C) seed weight. Air temperature was measured at each site.

No meteorological data excepting for air temperature were available for site B during the study period. In this maize growing season, precipitation from November to April was 1053 mm at site A and 1244 mm at site C. Mean air temperatures during the same period were 25.3°C at site A and 21.6°C at site C, with total solar radiation values of 22.2 and 20.2 MJ m^{-2} d^{-1}, respectively. Wind speed averaged 0.9 m s^{-1} at site A and 1.3 m s^{-1} at site C. Thus, the weather at the higher altitude of site C was cooler, windier, and wetter, with less solar radiation.

3. Results

The flowering date was earlier in the control treatment at sites A and B than at site C, even though the sowing date was earlier at site C (Table 1). At all sites, the flowering date was delayed by 8 to 46 days by the delayed sowing date. At site A, the period from sowing to flowering was not affected by the delayed sowing, but at sites B and C, the period was increased by 10 to 27 days as a result of the delayed sowing.

The grain yield in the control treatment was greater than 1000 kg ha^{-1} at sites A and B, but the yield at site C was less than 300 kg ha^{-1} for all sowing dates (Table 2). This difference resulted from the higher individual grain weight per plant, not from differences in the number of plants that became established. The delayed sowing date did not affect grain yield at site A, but greatly reduced grain yields at sites B and C, by 30 to 100% (Table 2). Figure 1 shows the differences among the maize plants grown at site C after different sowing dates. Delayed sowing clearly reduced both plant height and biomass.

Table 1. Growth stages of maize sown at different sowing dates in the 2008/2009 growing season in southern Zambia.

Site	Farmer's field ID	Treatment	Sowing date		Emergence date		Flowering date		Period from sowing to flowering (days)		Location
A	ASn1	Control	4-Dec		7-Dec		30-Jan		57		Sianemba vill.
		10d later	13-Dec	(+9)	17-Dec	(+10)	7-Feb	(+8)	56	(-1)	
		20d later	23-Dec	(+19)	27-Dec	(+20)	19-Feb	(+20)	58	(+1)	
	ASm2	Control	4-Dec		-		30-Jan		57		Siameja vill. mukuti
		10d later	13-Dec	(+9)	-		-		-	-	
B	BCh2	Control	29-Nov		-		17-Jan		49		Chanzika vill. mukuti
		10d later	8-Dec	(+9)	-		5-Feb	(+19)	59	(+10)	
C	CSa1	Control	28-Nov		-		2-Feb		66		Siachaya vill. Gibson's field
		10d later	7-Dec	(+9)	13-Dec		27-Feb	(+25)	82	(+16)	
		20d later	17-Dec	(+19)	23-Dec		20-Mar	(+46)	93	(+27)	
	CSa2	Control	28-Nov		-		2-Feb		66		Siachaya vill.
		10d later	7-Dec	(+9)	13-Dec		27-Feb	(+25)	82	(+16)	
	CSa3	Control	28-Nov		-		1-Feb		65		Siachaya vill. Alfred's
		10d later	7-Dec	(+9)	13-Dec		27-Feb	(+26)	82	(+17)	

Values in parentheses represent the difference from the value for the control.

Table 2. Grain yield of maize sown at different sowing dates in the 2008/2009 growing season in southern Zambia.

Site	Farmer's field ID	Treatment	Grain yield kg ha^{-1}			Number of plants established 10^3 ha^{-1}		Individual grain weight g plant^{-1}	
A	ASn1	Control	1157	±105		26.8		43.2	
		10d later	1205	±207	(1.04)	30.0	(1.12)	40.2	(0.93)
		20d later	1214	±115	(1.05)	37.5	(1.40)	32.4	(0.75)
	ASm2	Control	1117	±137		23.7		47.1	
		10d later	740	±162	(0.66)	45.0	(1.90)	16.4	(0.35)
B	BCh2	Control	1956	±166		24.6		79.6	
		10d later	1375	±261	(0.70)	30.0	(1.22)	45.8	(0.58)
C	CSa1	Control	197	±71		22.6		8.7	
		10d later	10	±9	(0.05)	26.3	(1.16)	0.4	(0.04)
		20d later	0	±0	(0.00)	17.5	(0.77)	0.0	(0.00)
	CSa2	Control	252	±45		17.0		14.8	
		10d later	138	±67	(0.55)	33.8	(1.98)	4.1	(0.28)
	CSa3	Control	286	±87		18.9		15.2	
		10d later	26	±11	(0.09)	34.4	(1.82)	0.7	(0.05)

Values in parentheses represent the ratio of the treatment value to the control value. Grain yield ± SE (n =12 plot for Control, n = 4 plot for 10d or 20d later.

Figure 2 illustrates the relationship between two parameters: the difference in the duration of the period from sowing to flowering compared with that in the control, and the ratio of grain yield in the delayed sowing treatments to that in the control (the "relative yield"). There was clearly a close negative correlation between these parameters; that is, the increased duration of the period from sowing to flowering that resulted from delayed sowing reduced the relative yield. Figure 3 illustrates the relationship between the relative yield and the mean air temperature from sowing to flowering. Again, there was a close correlation between the two parameters, but this time the correlation was positive; low air temperatures at site C reduced the yield as a result of the delayed sowing.

Control 10-d-later 20-d-later

Figure 1. Maize plants at harvesting time after sowing on different dates at site C, the high-elevation site near Siachaya village, southern Zambia (Gibson's field; Table 1).

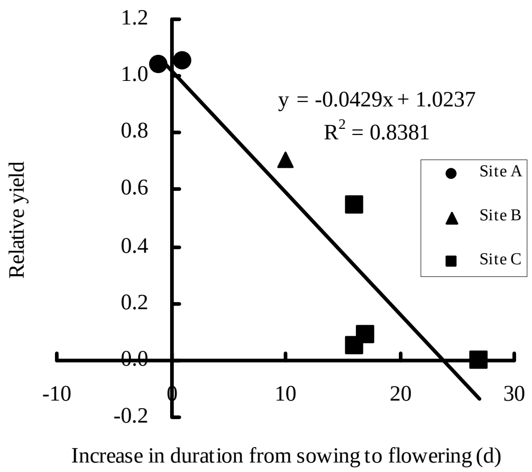

Figure 2. Relationship between the relative yield of maize in southern Zambia (the yield in the 10-d-later and 20-d-later treatments divided by that in the control) and the increase in the duration of the period from sowing to flowering compared with the control (as a result of the delayed sowing) compared with the control.

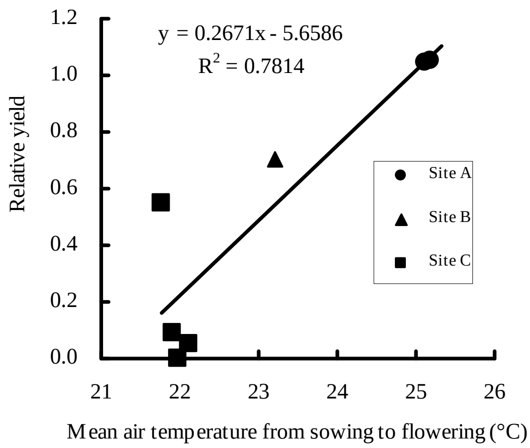

Figure 3. Relationship between the relative yield of maize in southern Zambia (the yield in the 10-d-later and 20-d-later treatments divided by that in the control) and the mean air temperature from sowing to flowering.

4. Discussion

Our study demonstrated that the yield response to delaying sowing differed among the sites (Table 2); at sites B and C (intermediate and higher altitudes, respectively), the delayed planting decreased the yield, but yield did not change at site A (at lower altitude). This confirmed that the current sowing dates used by local farmers were appropriate for growing maize in the study area.

There are several possible explanations for why later sowing decreased the maize yield, especially at sites B and C. First, water availability is one of the most important factors for maize production in Zambia. However, the precipitation during the 10 days after sowing and for the period from sowing to flowering was higher with 20-d-later sowing at site C (Fig. 4). Thus, the precipitation difference could not explain the yield difference. Second, because C_4 plants (including maize) grow better at higher temperatures, site C, with a lower mean temperature than site A (by 3.7°C) because of its higher altitude, might experience delayed early vegetative growth and reduced overall growth. This would lead to a slower rate of canopy development, resulting in lower ability to compete with weed species that are adapted to those conditions, although we did not measure the weed biomass and therefore cannot confirm this hypothesis. Higher wind speeds and lower temperatures at site C would also slow the canopy development. Third, it is possible that soil fertility is lower at site C. The dramatically lower yield at site C than at sites A and B (Table 2) might indicate that later sowing prevents the maize plants from utilizing the lower amounts of nutrient, and the problem may have been exacerbated by weed competition and leaching from the soil. In our future research, we will try to identify the factors responsible for the observed yield variations as a function of sowing date. It should also be noted that the yield level of all the villages in the present study was lower than the national average (1742 kg ha^{-1}). The results at sites B and C suggest that researchers should focus on improving the productivity of maize at earlier sowing dates, because later sowing decreased yield.

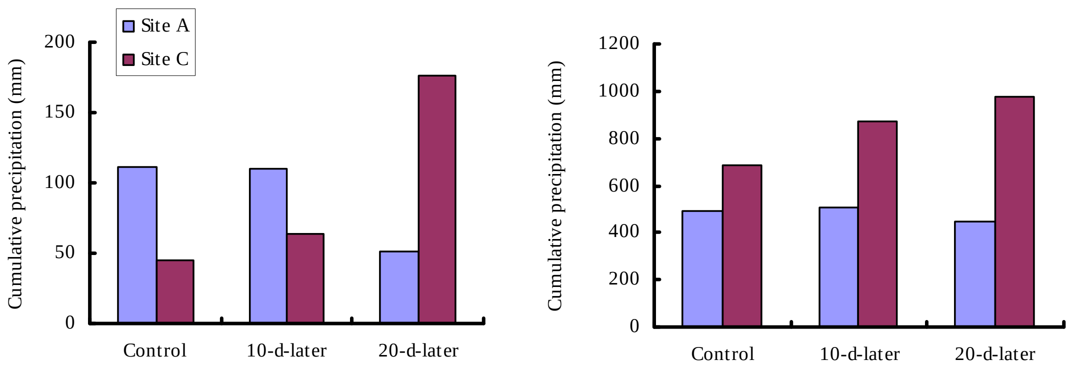

Figure 4. Cumulative precipitation for (left) the 10 days after sowing and (right) the period from sowing to flowering of maize for the control and for the two delayed sowing treatments in the 2008/2009 season in southern Zambia.

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A Preliminary Report on Social Network as Insurance in the Tonga Community

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Abstract

This report focuses on the support systems between households in the Tonga community, which provide a type of insurance through a social network. The report analyzes two support systems— quotidian support and extraordinary support. Quotidian support has the following features: (1) most of the members in this support system are close relatives; (2) the participants include household members and neighbors; and (3) the category of members often overlaps. Extraordinary support has the following features: (1) frequency and quantity of this type of support is linked to the phase of agricultural activity; (2) there are seasonal changes in the types of gifts given; and (3) the tendency to give certain types of gifts differs by location.

1. Introduction

Ecological influences create fluctuations in food production and income in rural villages of the semi-arid tropics (“SAT”). The Tonga people live in the SAT in Southern Province, Zambia. In addition to difficulties created by ecological influences, the Tonga people have limited or no access to insurance markets and administrative social security. This study aims to clarify how their social networks function as a type of insurance. The research is ongoing and this is a preliminary report.

2. Research Outline

The research sites are located in lower flat land (“Site A”), middle slope (“Site B”), and upper flat land (“Site C”) in Sinazongwe area, Southern Province, Zambia. The majority of residents at every site are the Tonga people.

The research methods are direct observation and interview through a questionnaire. The research topics are (1) the participation of individuals in the daily activities of food production and consumption and (2) the exchange of labor, money, food and other commodities.

3. Quotidian Support

The research focuses on how the support between households serves as a type of insurance through social network. This study analyzes two support systems: (1) quotidian support and (2) extraordinary support. This section describes quotidian support.

Participation in food production and consumption activities were researched as quotidian support systems and the relationship between participants and their background, such as blood relation and residence, were analyzed.

3.1 Food Production

The research focuses on the participation in collaborative work for agriculture and animal husbandry to analyze quotidian support in food production activity.

3.1.1 Agricultural Activity

Main agricultural activities are clearing, plowing, seeding, weeding and harvesting. The research shows that each activity was practiced by a household individually or several households collaboratively during the 2008–2009 rainy season.

Table 1 Rates of collaborative work in agriculture

Site	Village	Clearing			Ploughing			Seeding			Weeding			Harvesting			Total number of household
		+	-	+^-	+	-	+^-	+	-	+^-	+	-	+^-	+	-	+^-	
Site A	1	28%	28%	28%	56%	56%	54%	47%	47%	47%	13%	13%	13%	28%	28%	28%	72
	2	0%	0%	0%	64%	64%	64%	0%	0%	0%	0%	0%	0%	0%	0%	0%	42
Site B	3	0%	0%	0%	61%	61%	56%	39%	39%	33%	39%	39%	33%	50%	39%	33%	18
	4	16%	16%	16%	48%	45%	41%	48%	48%	43%	27%	30%	20%	34%	36%	25%	44
	5	0%	0%	0%	56%	56%	33%	33%	33%	33%	0%	0%	0%	0%	0%	0%	8
Site C	6	0%	0%	0%	77%	77%	77%	77%	77%	77%	0%	0%	0%	77%	77%	77%	90

In Table 1, '+' equals rates of households which helped others, '-' equals rates of households which were helped, and '+^-' equals rates of household which both provided help to others and were helped.

Values for '+', '-' and '+^-' might be different in this table; the difference between '+' and '+^-' equals the rate of households which helped others but were not helped. The difference between '-' and '+^-' equals the rate of households which did not help others but were helped.

Rates of collaborative work for each category differed widely. In many villages, the fields were cleared by fire, a method that each household can conduct individually. Therefore, the values for clearing were 0% in four of six villages. In contrast, plowing requires the use of two oxen and only a limited number of households own a pair of oxen. Therefore, the values for plowing were the highest, reflecting collaboration between households that do not own a pair of oxen and households that do.

3.1.2 Pastoral Activity

Among the Tonga people, kraal and grazing are important pastoral activities. Results of interviews conducted regarding pastoral activities in 2009 are provided in Table 2.

Table 2 Rates of collaborative work in pastoral activities

Site	Village	Cattle						Goat						Total number of household
		i	ii	iii	iv	v	i,ii&iv	i	ii	iii	iv	v	i,ii&iv	
Site A	1	3%	9%	19%	21%	48%	33%	-	-	-	-	-		72
	2	29%	5%	17%	12%	38%	46%	26%	0%	31%	2%	40%	28%	42
Site B	3	11%	11%	11%	17%	50%	39%	-	-	-	-	-		18
	4	30%	5%	11%	5%	50%	40%	27%	0%	0%	0%	73%	27%	44
	5	25%	0%	25%	0%	50%	25%	-	-	-	-	-		8
Site C	6	38%	10%	12%	24%	16%	72%	20%	0%	14%	0%	66%	20%	90

In Table 2, category 'i' equals rates of households which owned animals and shared kraal with other households. Category 'ii' equals rates of households which owned animals and kraal and were helped by others with grazing activities. Category 'iii' expresses rates of households which owned animals and kraal and completed grazing activities by themselves. Category 'iv' equals rates of households which did not own animals (cattle or goats) but helped other households in grazing activities. Category 'v' equals rates of households which did not own animals (cattle or goats) and did not help other households with grazing activities.

Households which collaborated in management of kraal are included in category 'i'. Households which collaborated in grazing activities are included in categories 'i', 'ii' and 'iv'. The data shows that the number of households participating in grazing activities is higher than the number of households that own kraal.

The values for grazing differed significantly based on the categories of cattle and goats. Fewer households collaborated in grazing activities for goats than for cattle. In particular, category 'iv' shows a marked difference; few households that did not own goats helped others with grazing activities for goats.

In contrast, many households collaborated in grazing activities for cattle. Since all households need a pair of oxen for plowing but not all households own oxen, many households that did not own cattle still helped others with grazing activities for cattle as a type of collaborative assistance in response to their expected need to borrow an ox or a pair of oxen for plowing.

3.1.3 Comparison between Agricultural and Pastoral Activities

Rates of collaborative works are different depending on each activity. But participation of households was similar. In particular, households that participated in plowing and grazing overlap. The need of most households for oxen to conduct plowing translates into most households participating in cattle grazing.

3.2 Food Consumption

Analysis of data gathered in 2009 through interviews of residence and commensality members shows quotidian support in food consumption activities. Members of a residence are people whose houses face the same yard (Figure 1, left diagram). Members of commensality are people who eat meals together (Figure 1, right diagram).

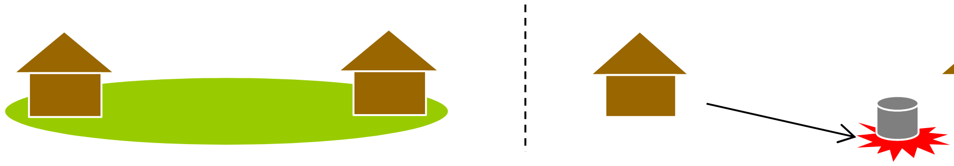

Figure 1 Membership of consumption

3.2.1 Residence Members

Table 3 shows values for residence members. Residence members are households that share their yard with others. In the table, values for Site A are higher than Sites B and C.

Intervals between houses in Site A are likely to be denser than site B and C. The higher density may be related to more households in Site A that share yards than in Sites B and C. Future research will analyze the causal relationship between density of houses and residence members with GPS data.

3.2.2 Commensality Members

Table 3 shows values for commensality members. Commensality members are households whose members eat meals with others. In the table, values for Site B are lower than Sites A and C. Gaps between values for Site A and B may be related to the intervals between houses.

Table 3 Rates of memberships in consumption

Site	Village	Number of household	Residence members	Commensality members
Site A	1	72	47%	46%
	2	42	48%	55%
Site B	3	18	33%	33%
	4	44	22%	33%
	5	8	22%	22%
Site C	6	90	12%	43%

3.2.3 Comparison of Both Memberships for Consumption

Table 3 expresses that rates of Site A are high and of Site B are low in memberships for consumption. This difference may be related to the intervals between houses.

The table shows that rates for memberships of residence and commensality were almost equal in Villages 1, 3 and 5. In addition, rates of residence were less than commensality in Villages 2, 4 and 6. This can be described as "membership of residence = or < membership of commensality"; households that share the yard eat together (Figure 2, left diagram), but households that do not share the yard also may eat together (Figure 2, right diagram).

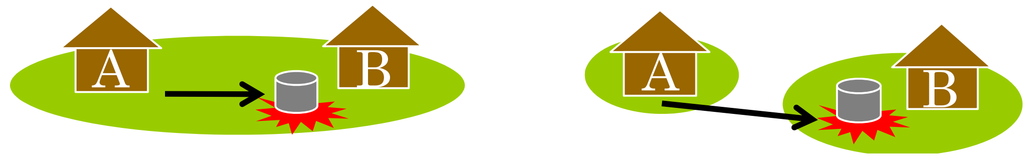

Figure 2 Relation between members of residence and commensality

3.3 Background of Quotidian Support

Analysis of the data gathered on the relationships among members for food production and consumption activities provides an understanding of quotidian support. These activities share three common features: (1) most of the members consist of close relatives; (2) membership is not limited to members of residence and can include neighbors; and (3) memberships often overlap.

However, some households have large gaps between memberships of food production and consumption because of the absence or shortage of cattle. For example, members of Households B and C in Figure 3, left diagram, shared the yard and ate meals together in 2008–2009. Members of Household B worked to plow and graze with members of Household A, and members of Household C did the same with members of Household D. Households B and C, which was a parent-child relationship, were members of joint food consumption, but they could not be members of joint food production since neither owned an ox. Therefore, Household B joined with Household A, a close relative, and Household C joined with Household D, also a close relative, in food production to borrow two oxen owned by Households A and D for plowing. Figure 3, right diagram displays the blood relationships between Households A, B, C, and D. The head of Household B was a nephew of the head of Household A's deceased spouse. The head of Household D was an uncle to the head of Household C.

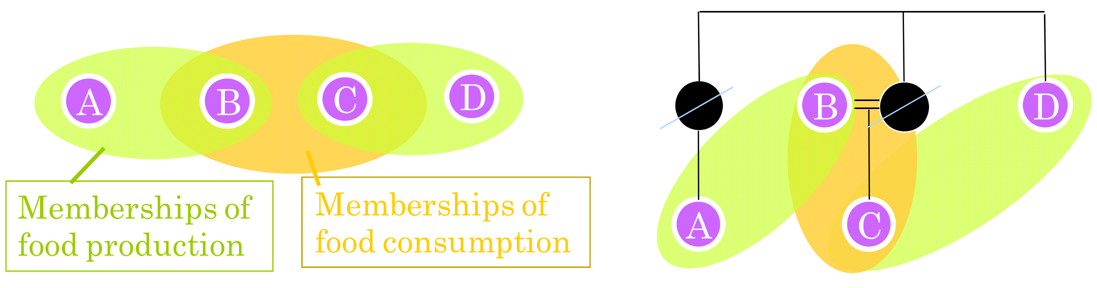

Figure 3 Memberships and blood relationships of household A, B, C

4. Insurance Among Households: Extraordinary Support

Among the Tonga people, giving and receiving is practiced irregularly. This includes gifts, trade, loans and reward for labor. This report focuses on gifts given as extraordinary support. Below is an analysis of the differences among seasons and locations in the case studies. This section deals with case studies of Households E and F.

4.1 Case Study of Household E

Members of Household E live in Site A and consist of six people; a female householder, her two children, her mother, her niece and the niece's baby. The head of the household is in her late forties.

Figure 4 shows the frequency of gifts given each month in the period March–November 2009. The gifts consist of staple food, supplemental food, cooked meals, cash and other items.

Total frequency declined rapidly during March–June and remained at a low level after June. The frequency of giving staple food reduced by half during March–April and continued to drop by a quarter during April–May. After May, staple food was rarely given. Gifts received by Household E decreased gradually between March and July, and between August and October, they rarely received gifts. Both giving and receiving increased slightly in November.

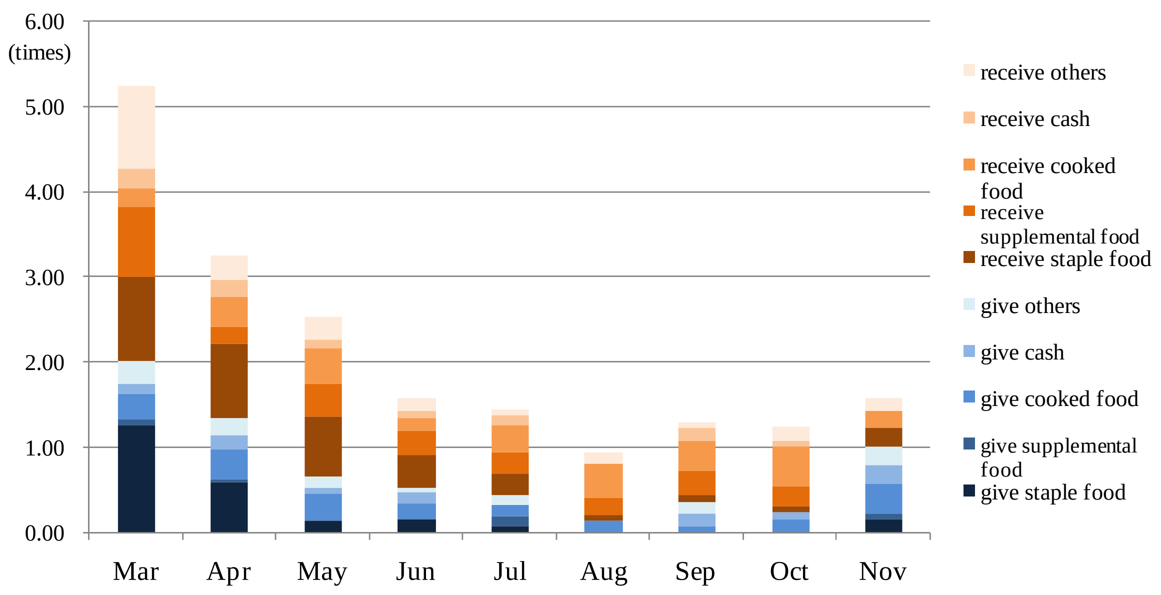

Figure 4 Frequency of gifts per day for household E

The frequency of gifts is linked to the cultivation of cereals, particularly maize which peaks around harvest season. Gift giving is highest in March at the beginning of harvest. During the maize harvest, fresh cobs were often given and received. Also, dried grain and flour were frequently given and received. Until the dry maize was harvested those suffering from food shortage received assistance from others. In April, during the dry maize harvesting, cooked meals and small amounts of harvests were often given and received.

Figure 5 shows the monetary value of gifts measured in the Zambian currency Kwacha each month during the period March–November 2009. The details of the values are the same as Figure 4.

The monthly total values were high during May–July despite lower frequency of gifts than in

March and April. After the harvest had been completed, households had enough time to visit other households and opportunities to give and receive large amounts of gifts. Since November was seeding period and households' food stocks had been depleted and were in double demand for meal and seed, the monetary value of staple food rose sharply.

Through an analysis of Household E, it became evident that the frequency and monetary value of gifts are linked to the phase of agricultural activity, especially maize cultivation. Because agriculture is the main livelihood activity of most people and maize is the main staple food in the research sites, there are seasonal changes in frequency and monetary value of gifts. For example, during the harvest period of fresh maize in March 2009, harvested cobs were given and received frequently. During the harvest period of dry maize in April 2009, cooked meals and small amounts of harvests were given and received. The amount of giving and receiving of staple food rose in November 2009 during the seeding period. The frequency and monetary value of staple food increased around periods of harvest and seeding.

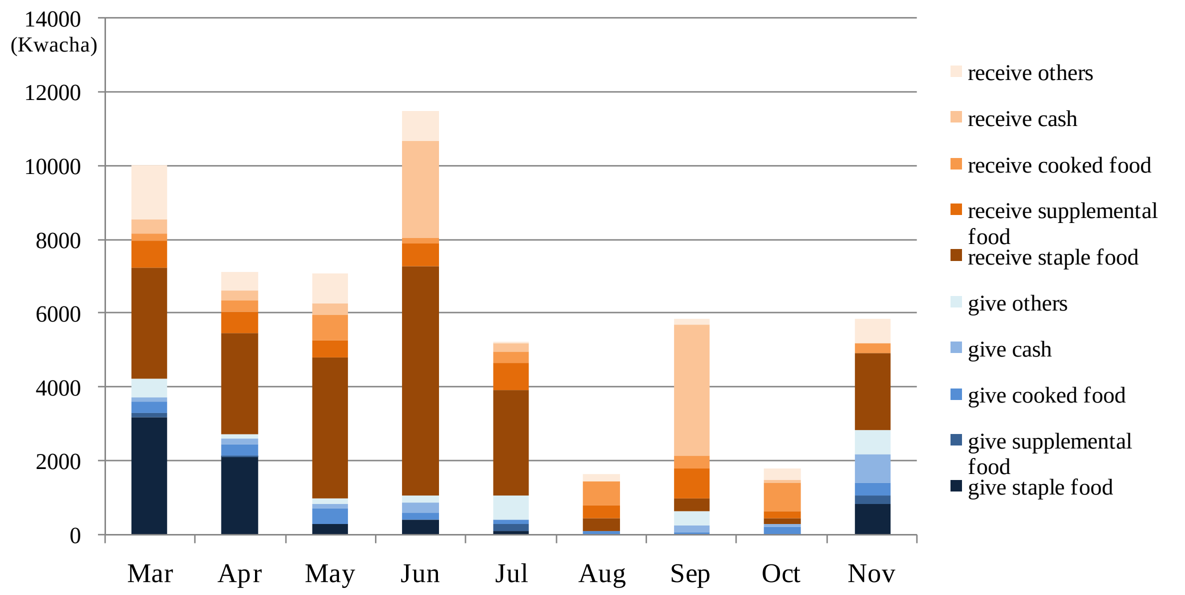

Figure 5 Monetary values for gifts per day for Household E

4.2 Case Study of Household F

The members of Household F live in Site C and consist of eight people: the head of household, his wife, their five children, and the niece of the head of household. The head of household is in his late thirties.

In Household F, the total frequency of gifts declined rapidly in the period March–May 2009 and continued to drop lower. However, the monetary values of gifts were extremely high in May, August and October in the form of staple food, which was different from Household E's trend. To understand the gift giving trend for household F, each staple food crop is analyzed.

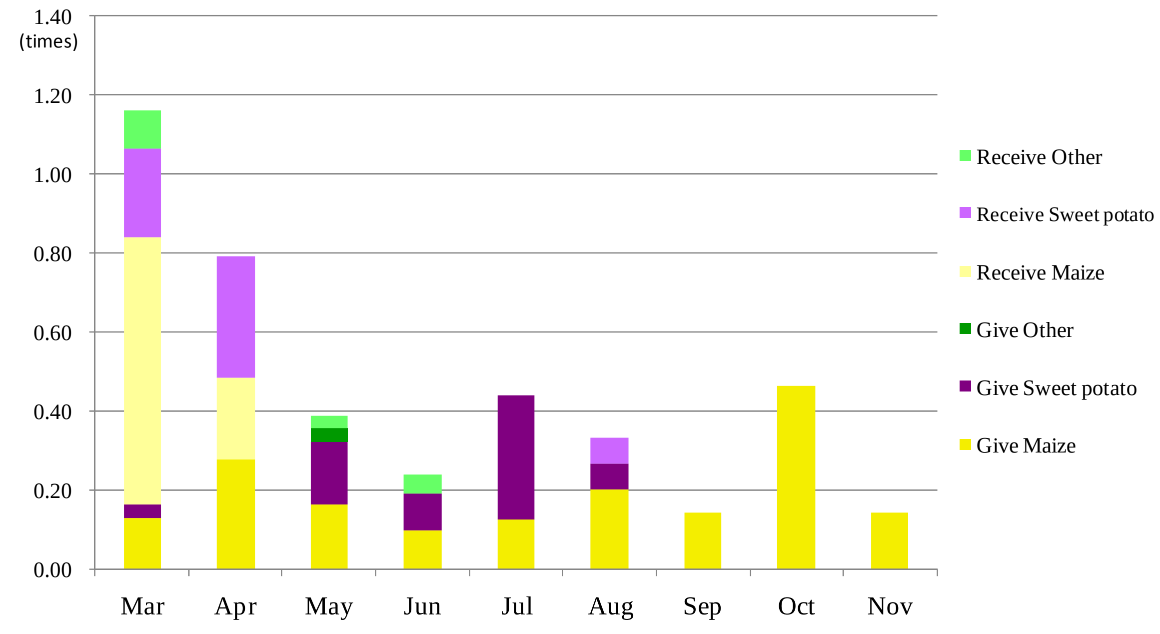

Figure 6 Frequency for gifts of staple food per day in Household F

Figure 6 shows the frequency of gifts of staple food each month during March–November 2009. Staples foods include maize, sweet potato, cassava, and pumpkin. The frequency of giving maize was high in March and April because it was harvest season and maize cobs were plentiful. Sweet potato was given and received between March and August.

Figure 7 shows the monetary value of gifts of staple food in the Zambian currency Kwacha each month between March and November 2009. The details of values are the same as Figure 6. In March and April, the monetary value was small in comparison to the frequency of gift giving and receiving. Since it was harvest season, small amounts of staple food such as maize cobs were given and received frequently. In May, the total value increased rapidly, corresponding with the peak season for sweet potato harvest. The value of sweet potatoes given and received decreased gradually until August. In August, when households started seeding maize in the field for dry season, the demand and value rose. Also, in October, the demand and value of maize increased, corresponding with the season for seeding maize.

It is apparent that Household E and F peaked differently. Household F experienced peaks during the rainy season for maize and during the dry season for sweet potato and maize. Since Household F is located in Site C which includes abundant lands suitable for dry season farming, it has several cultivation seasons. In contrast, Household E is located in site A, which lacks sufficient lands for dry season farming. Therefore, Household E cultivates only once during the rainy season.

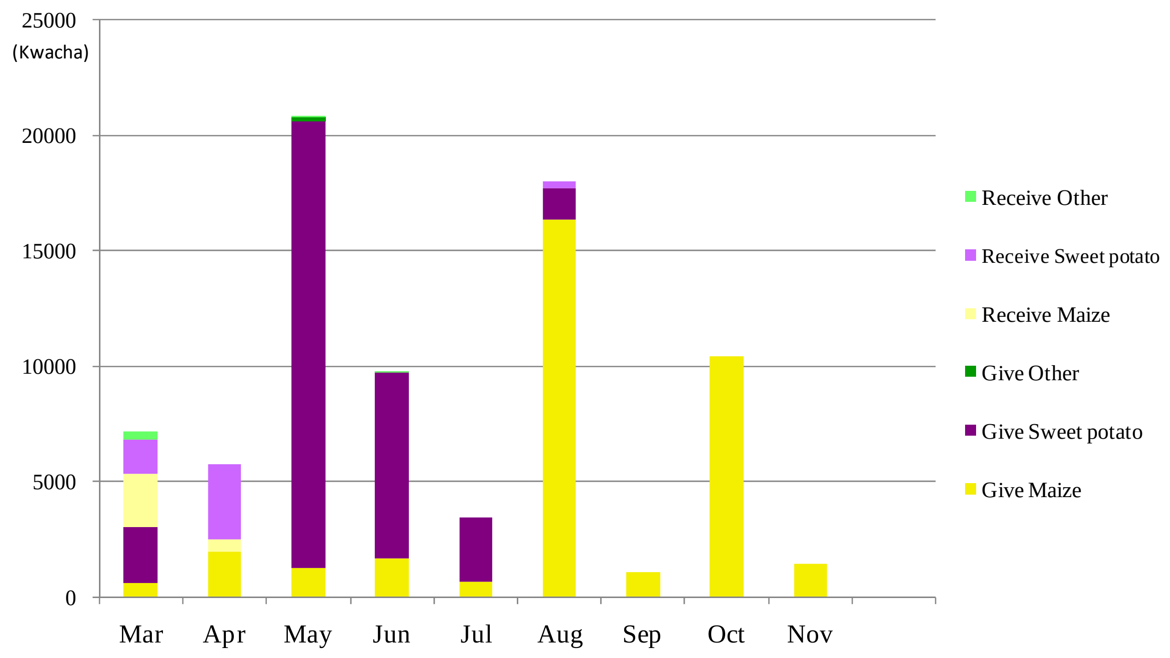

Figure 7 Monetary values for Gifts of Staple Food per day in Household F

4.3 Findings Through Analysis of Gift

The data discussed in Section 4 shows (1) the frequency and monetary value of gifts are linked to the phase of agricultural activity since agriculture is the main livelihood activity of most people in the research sites; (2) there are seasonal changes in frequency and monetary value of gifts wherein staple food increases around periods of harvest and seeding; and (3) The differences in gift trends are caused by differences in location. In particular, accessibility to dry season fields produces multiple agricultural seasons, which influences gift trends.

Future research will analyze the relationship between givers and receivers, focusing on the distance between their residences and their blood relationships.

Coping Strategies to the Damaged Crops by Heavy Rain in 2007/2008

- A case of Sinazeze, Southern Province of Zambia -

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We aim to use a multi-spatial and temporal approach to trace people's livelihoods from a village to a regional level. For this, we have accumulated various spatial data and considered the seasonal and inter-annual changes. The principal data is composed of satellite images, aerial photographs and a crop allocation map determined by field investigation. Our concept of a multi-spatial and temporal approach is used to integrate the various kinds of data.

In FY2009, we have analyzed how the villagers cope with serious damage to crops from heavy rain in 2007/2008 by using the crop allocation map in 2007/2008 rainy season and 2008 dry season, and the results of the interviews about cash income situation at each household in FY2007 and FY2008.

The annual rainfall in site A and B was recorded in more than two times of the long term average 694.9 mm/yr in Sinazongwe district. According to the area totalization from the crop allocation map, about 20% areas of all maize fields in our study Site A, B and C were damaged from heavy rain. As for the every site, the ratios of damaged area were 34%, 28% and 4% in Site A, B and C respectively. There are the differences among three sites. It is supposed that the topographic differences are affected. From GIS analysis of the damaged fields during 2007/2008 rainy season, flood damages are concentrated in ill-drained fields in Site A lower terrace, steep fields in Site B mid-escarpment, and valley bottom fields in Site C upper terrace. As for the coping to flood damages, about 60% of all damaged fields were land in fallow and the other fields were used as crop field after damage. 22% of damaged fields were planted maize again in Site A. Contrastingly, 26% of damaged fields were planted sweet potato in Site C.

We also measured the area of damaged fields for each household. The ratio of households of which more than 80% fields were damaged was about 20 % in Site A. Accordingly we compared the cash income situations in FY2007 and FY2008 for those households. In FY2007, those households got cash by selling Maize and Cotton mainly. However, the way to get the income was changed to selling domestic animals, fisher and piece work instead of selling Maize in FY2008. This is also one of the coping strategies by non-agricultural activities.

In near future, we will clarify other coping strategies by giving and receiving of food and labor force in relatives and neighbors networks.

NGOs' Activities and Food Security Programmes in Sinazongwe, Zambia

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Abstract

In the Sinazongwe district, several NGOs have implemented their development and relief programmes. Among all, World Vision (WV) is a main NGO providing food aid independently from the Zambian government. In FY 2009 research, we focused on the NGOs' food security programmes by collecting the documents and observing their activities. The purpose of our research is to analyse how food aid by various actors has impacts on rural communities, especially through examining the role of the government institutions and other organisations.

This paper firstly shows the outline of the WV's two joint programmes, C-SAFE (2003-2006) and C-FARM (2007-2010). These programmes have been implemented in southern African countries including South Africa, Malawi, Mozambique and Zambia. Several NGOs such as CARE international, Catholic Relief Service (CRS) and the WV have participated to these programmes in Zambia. The WV has been responsible for the implementation in the Sinazongwe district.

The research on the WV's activities in Sinazongwe reveals that the current programme has only covered communities under relatively better condition near main roads due to the limited resources and difficulties of access. Although the food aid programme of the WV is carried out according to their own guideline independently from the government focusing on targeting of beneficiaries, some NGOs often work for the government institution as in the case of Kaluli Development Foundation (KDF). The KDF has implemented the government food relief project as a local distributor contracting with the Disaster Management and Mitigation Unit (DMMU).

In the 2009 fieldwork, we observed the actual implementation of the NGOs' food security programmes and collected information about their activities mainly from the WV and the KDF. Our research issue in FY 2010 will be more focused on local communities through an intensive field study about food security situations at a selected village and the impacts of relief activities on local livelihood. By integrating the data collected, we will try to analyze the local perceptions and responses to the food security programmes such as food aid. Through the research, we are expecting to reveal the social and political impact of food security institutions on the resilience of rural communities.

1. Two Food Aid Programmes of the WV in the Sinazongwe: 2003-2009

In the Sinazongwe district, the WV Zambia sets up two offices, one is the 'Area Development Program (ADP)' office located at Sinazongwe town, and another is the 'Humanitarian and Emergency Affair (HEA)' office at Maamba town, which more focuses on relief programmes with food aid. At the HEA office, about 17 officers were working in 2008-2009. Our research has been conducted mainly about the activities of the HEA office.

Until 2004, the WV HEA in Sinazongwe had worked for the Disaster Management and Mitigation Unit (DMMU) under the Office of Vice-President (OVP) and implemented the government relief programme as the local food distributor. In 2005, its role was replaced by a local NGO, Kaluli Development Foundation (KDF). The WV has held their own joint programmes named, ‘Consortium of Southern Africa Food Emergence (C-SAFE)’ from January 2003 to September 2006 (from January to September 2006 in Sinazongwe), and ‘Consortium for Food Security Agricultural, AIDS Resilience and Marketing (C-FAARM)’ from September 2007 to August 2010 (planned).

The main donor of both programmes is the USAID. Several NGOs, such as CARE international, WV, Catholic Relief Service (CRS) and Land O’ Lakes, have collaborated and implemented those programmes in southern African countries such as South Africa, Mozambique, Malawi, Zimbabwe, and Zambia. In the southern province of Zambia, four districts, Sinazongwe, Choma, Mazabuka, and Kalomo, were selected as targeted food insecure areas.

The WV has taken charge of the programme implementation in the Sinazongwe district. In the district, the C-SAFE started in January 2006 as an emergency relief just after a severe drought in 2005/06 (the food aid actually started from February to March in 2006). In C-SAFE programme, it distributed foodstuffs (cereal and pulse, usually wheat and lentil) to targeted vulnerable persons and/or households that included pregnant and lactated women and children (PLWC), chronically ill and HIV (CI/HIV), and orphans and vulnerable children (OVC). Out of all food resources, 70 percent was provided to the targeted persons as a free relief called as ‘Targeted Food Assistance (TFA)’, and 30 percent was to the vulnerable but viable persons through a food for work, ‘Food for Asset (FFA)’.

Table 1 shows the number of the C-SAFE’s beneficiaries on July 2006 in Sinazongwe. In that month, 9485 TFA beneficiaries and 2697 FFA beneficiaries received relief food (TFA: 8.3 kg cereal and 2 kg pulse per person, FFA: 50 kg cereal and 5 kg pulse per person). Totally, 99.026 metric tons of cereal and 21 metric tons of pulse were distributed at that time. These monthly figures of distributed food changed from month to month according to the number of retargeted beneficiaries and food security situations in this area. The relief distribution started in April 2006 at 20 centres, or Food Distribution Points (FDPs), covering the district; Buleya Malima, Chimonsele, Chiyabi, Dengeza, Kanchindu, Lusinga, Malabali, Malima, Mubike, Munyati, Muuka, Muziyo, Nkandabwe, Nyanga, Siameja,Sianyuka, Ngoma, Sinakasikili, Sinanjola.

Table1. C-SAFE Food Distribution for a month in Sinazongwe district (July 2006)

		Boys	Girls	Males	Females	Total bens.	Total HHs
TFA	PLWC	1236	1282	777	924	4219	783
	OVC	1191	1042	552	826	3611	703
	CI/HIV	420	386	365	484	1655	334
	Subtotal	2847	2710	1694	2234	9485	1820
FFA		830	785	512	570	2697	406

Source: Based on a document of the WV HEA, Sinazongwe office
Note: ‘bens.’ = ‘beneficiaries’, ‘HHs’ = ‘households’

Table 2. C-FAARM Food Distribution for a month in Sinazongwe district (September 2008)

		Boys	Girls	Males	Females	Total bens.	Total HHs
TFA	HIV	43	42	24	30	139	26
	Non-HIV	568	523	290	460	1841	379
	Subtotal	611	565	314	490	1980	405
FFA		551	563	277	352	1743	244

Source: Based on a document of the WV HEA, Sinazongwe office

While the C-SAFE focused mainly on a relief for the vulnerable households affected by severe drought in 2005/06, the C-FAAM, which stared in 2007 as its successive programme, focused more on development projects through the FFA. According to the policy, 30 percent of all food resources should be used for the TFA, and 70 percent for the FFA.

Table 2 shows the number of the C-FAARM's beneficiaries in the Sinazongwe district in September 2008. As the C-FAARM lays emphasis on support for HIV carriers, the TFA category of beneficiary was modified from the previous three divisions to simply 'HIV' or 'Non- HIV'. However, as an officer said that the beneficiaries were selected mainly from female household heads, high dependent ratio households, OVC, and HIV carriers, most of the beneficiaries are categorised as non-HIV. In the month of Table 2, totally 28.634 metric tons of cereal and 5.18 metric tons of pulse were distributed (food ration is the same with the C-SAFE). The food distribution is now carried out at 10 FDPs; Kanchindu Central, Mweemba, Siansowa, Ngoma, Mweezya, Nkandabwe, Muziyo, Munyati, Sinanjola, Siamvwemu.

In the C-FAARM programme, the FFA is not necessary implemented in every month. If there is no work programme for the FFA, no foodstuff is distributed. Because of some technical difficulties of the planning and implementing, it was only twice (September 08 and July 08) that the FFA food was actually distributed since the programme started in September 2007 (up to September 2009). A WV officer told me that several FFA projects have been finally arranged because the work for making a plan of the public work and arranging with the local people took much times. In September 2009, the training of a treadle pump for small-scale irrigation started as a FFA project. The WV provides necessary training, equipments and supplies to the FFA beneficiaries.

As table 2 shows, in terms of the number of beneficiaries as well as the amount of the distributed food, the scale of food aid has become much smaller than that of the previous C-SAFE. In an emergency, however, some additional relief foods have been distributed. From March to May in 2008, for example, the flood affected 2196 persons (392 households) received 3 months' relief foods (the same ration with TFA) through the C-FAAM. This new programme has limited the food distribution only for the most vulnerable persons and periods to avoid the dependency on food aid.

2. Seed Distribution by the C-FAARM

To enhance the agricultural productivity and promote the crop variety is one of the main purposes of the C-FAARM. For achieving it, the programme provides several kinds of crop seeds to the ‘vulnerable but viable’ and ‘vulnerable’ farmers selected by communities (approximately 200-350 beneficiaries, 30-40 households selected at each centre). Since the beginning of the programme in 2007, the seed distribution has been continued twice a year (at winter cropping season from April to June and at farming season from October to December). The kinds of seeds are decided according to the ‘seed monitoring’ that surveys local farmers’ crop variety, their priorities, cultivate area of crops, the amount of crop yield, cultivation plan for next season and so on.

Table 3 shows the varieties of seeds that have been distributed by the C-FAARM. Until September 2009, the seed distribution has been carried out five times. Not only staple crop such as maize and sorghum, but also vegetables and tubers have been distributed. The kinds of seeds distributed are different from a centre to a centre based on the seed monitoring. Even some kinds of seeds are newly introduced to this area. As the sunflower, for example, is not so common in Sinazongwe and people have a difficulty for its marketing, the WV supports the farmers by purchasing and selling it to a dealer in Monze. Those seeds are procured by the WV from some Zambian companies.

Table 3. Implementation of Seed Distribution and the Varieties of Seeds

Year/ Season	Distributed Seeds Varieties
2007 Nov	Sorghum, Maize, Ground Nuts, Cowpeas
2007 Dec	Maize, Sweet potato vines
2008 July	Cabbage, Cowpea, Tomato
2008 Dec	Cowpeas, Sweet potato vines, Sunflower
2009 May	Tomato, Cabbage, Maze

Source: Based on a document of the WV HEA, Sinazongwe office

Table 4. C-FAARM Seed Distribution in Sinazongwe (November 2007)

Category of Beneficiaries								Amount of Distributed Seeds (kg)			
Vulnerable but Viable				Vulnerable							
M	F	HH	Total	M	F	HH	Total	Sorghum	Maize	Cowpeas	Groundnuts
735	799	190	1534	521	569	150	1109	425	850	425	1700

Source: Based on a document of the WV HEA, Sinazongwe office

Note: a) M=Male (including boys), F=Female (including girls); b) The units of distributed seed were 2.5 kg Sorghum, 5 kg Maize, 2.5 kg Cowpeas, 10 kg Groundnuts per a household; c) In most cases, only two kinds of seeds were distributed in each centre.

Table 4 shows a case of the seed distribution in November 2007. Totally more than 2600 farmers received at that time. It is said that those beneficiaries are not always poor and vulnerable, but selected basically from those who have farm fields and labour forces. There are about four “lead farmers” in each centre who are selected from literate and highly motivated model farmers. They have received the WV’s trainings on conservation farming and are responsible for the selection of the seeds recipients. An officer noticed that in some case even affluent farmers such as an area councillor were involved as the seed beneficiaries.

As mentioned above, the programme scale was cut down in the C-FAARM. And the programme priority has been changed from relief to development and productive agriculture. The number of food distribution centres decreased from 20 to 10, and the programme covered area was sharply reduced. Especially, the remote area in the district such as Chiyabi and Siameja is now not covered. The WV HEA coordinator explained it on the ground of the limited resource and difficulties of access. It was actually observed that the WV HEA office owned only two vehicles (during the research in 2009, one of them was under repair) and that the field officers could not get necessary transportation to their field sites. Ten centres in the C-FAARM are now all located near from main roads and easily accessible. In terms of necessity of development, however, some villagers in Siameja complained of the WV withdrawal pointing out that there were almost no NGOs’ activities in the area thereafter.

3. The Activities of the Kaluli Development Foundation

The Kaluli Development Foundation (KDF) was established in 1998. It is the only local NGO that works in the Sinazongwe district. The predecessor of this organisation was ‘Gwembe South Development Programme’ that started in the 1970s as a relief for the resettled people by the construction of Kaliba Dam. The programme was supported by the Gosina Mission (Germany), GTZ, and the Zambian government. Since the Gosina Mission now provides funds only for the management cost of the KDF, other donors support specific programmes such as ‘Sustainable Agriculture Programme’ supported by the Bread for the World (Germany), ‘Food Security Pack (FSP)’ by Programme Against Malnutrition (PAM, Zambia) and ‘Water Supply and Sanitation Programme’ (phased out in 2007) by the Christian Aid (UK).

Among all, the FSP programme is carried out all over the country as one of the largest food security programmes in Zambia, which is supported by the Department for International Development (DFID, UK), the Norwegian government, FAO and so on. The KDF takes charge of its implementation in the Sinazongwe district. In the district, it started in 2001. The FSP lends seeds of maize and cowpeas, and fertilizers to the farmers who own wetlands for winter cropping. After harvesting, the farmers would give back to the community, for example, 20 kg maize for the seeds, 5 kg maize for the cowpeas, and 50 kg maize for the fertilizer. The community utilizes the repaid maize for the next season’s lending and other purposes by selling them. It is called a ‘Community Grain Bank’. The way of the utilization of the resources largely leaves the community’s initiative. In a community, they once bought goats and distributed them to the villagers who are expected to pay back a part of the reproduced goats to the community. The KDF has implemented the FSP programme at the several agricultural camps in the district and followed the communities' activities.

As 'a project implementing partner' of the Zambian government, the KDF also carries out the relief food distribution by making a 'Memorandum of Understanding' (MOU) with the DMMU. The MOU prescribes the relief objective, the role of a project implementing partner, the way of distribution, the obligations of both sides and so on. Since 2005, the KDF has been assigned responsibilities such as the receiving relief foods, the delivery to 32 satellite committees in the district, and the monitoring and reporting on the distributions for the DMMU.

In a case that the researcher observed, for example, on 26th June 2008, the district commissioner noticed to the KDF about the release of 100 metric tons of relief maize from the DMMU. On 1st July, the KDF signed up a MOU with the government (with a national coordinator of the DMMU). The MOU mentioned the purpose of food aid as the following: a) To supplement the food requirements of the affected population particularly vulnerable households, until the next harvest in 2008; b) To enhance the coping mechanisms of the most vulnerable groups in the food deficit areas. And it described the main project activities as follows: a) Selection of beneficiaries; b) Food dispatches to final delivery points by suppliers; c) Distribution of food rations to beneficiaries; and e) Monitoring and reporting. The government also provides that 80 percent of food should be allocated for 'Food for Work' participants and 20 percent for vulnerable people as a free support.

Until the end of June, even before the conclusion of the MOU, 100 metric tons of maize had been delivered to the storage in Maamba town. Nevertheless, the food distribution was rather delayed due to the breakdown of the KDF owned truck and it finally started from the end of August. Moreover, mainly because of the poor condition of the roads in the district, the delivery of the relief food to 32 distribution points took more than three weeks by using only one track in a bad condition and another tractor. At each food distribution points, the Satellite Disaster Management Committee (SDMC) takes charge of the beneficiary selection and the food distribution. As a smallest unit of the national disaster management institution, the SDMC usually consists of several local villages.

Table 5 shows the number of beneficiaries and the amount of relief maize in the case from August to September in 2008. The amount of allocation to the SDMCs was decided simply based on the household numbers in each SDMC. It is no doubt that the scale of this government food aid is more extensive than the current programme of the WV especially in terms of the covered area as well as the number of beneficiaries.

In order to implement the food distribution, the KDF receives a half of the management cost in advance and receives the remainder after the completion of the task. The KDF manager, however, pointed out that the payment from the government was frequently delayed and they had a serious financial problem on their activities. Moreover, because the amount of relief food and its timings are not fixed and it is noticed to the KDF just before the delivery, the implementation of food aid distribution is usually delayed and poorly timed.

Table 5. The Government Food Aid Distributed by the KDF in August/ September 2008

SDMCs	Estimated No. of beneficiaries	Maize Allocation (mt)	No. of 50 kg bags
Chiyabi	105	3.2	64
Malima	118	3.6	72
Sianyuka	74	2.25	45
Sinanjola	127	3.9	78
Munyati	170	5.2	104
Lusinga	80	2.45	49
Buleya Malima	168	5.15	103
Muziyo	85	2.6	52
Malabali	25	0.75	15
Sinazeze	167	5.1	102
Nkandabwe	163	5	100
Siamuyala	163	5	100
Sinazongwe	137	4.2	84
Mweezya	88	2.7	54
Sialwala	42	1.3	26
Sinakasikili	82	2.5	50
Sikaneka	139	4.25	85
Maamba	103	3.15	63
Sinankumbi	103	3.15	63
Sulwegonde	75	2.3	46
Chimonselo	65	2	40
Kanchindu	214	6.55	131
Siansowa	101	3.1	62
Namafulu	41	1.25	25
Sinakoba	57	1.75	35
Muuka	69	2.1	42
Dengeza	65	2	40
Nyanga	60	1.85	37
Siameja	96	2.95	59
Siawaza	23	0.7	14
Kafwambila	142	4.35	87
Siampondo	87	2.65	53
Total	3234	99	1980

Source: Based on a report of the KDF submitted to the DMMU.

Note: a) At this time, the number of the bags delivered to Sinazongwe was 1999. The reason of the deficit of 19 bags is not clear from the report; b) The estimated number of beneficiaries is calculated based on the standard ratio set by the government (80% for FFW participants with 50 kg per person and 20 % for free support to vulnerable people with 12 kg per person).

4. Research Summary and Further Issue

In FY 2009 research, we focused on the NGOs activities and the food security programmes in Sinazongwe mainly based on the documents of these organisations and field surveys. This research reveals that the NGOs have implemented several kinds of programmes for enhancing the food security in the district, but some of them have faced some issues mainly because of the access difficulties, poor facilities and equipments, and some management problems. At the same times, as those several programmes including the government's food aid have not been incorporated and coordinated well, the effectiveness and achievements of these programmes are still not clear in terms of the improvement of food security in the district as a whole. Particularly, although various kinds of programmes are implemented by the NGOs in the limited areas where are easily accessible from main roads, the situation of remote areas is hardly followed up by any organisations.

Our research issue in FY 2010 will be focused on an intensive field study about how those food security programmes of the NGOs and government institutions have had impacts on local communities. By interviewing with the NGOs stuffs, the government officers, and local farmers, we will try to investigate the effectiveness of food relief programmes and the local responses to them. Through the research, we are expecting to reveal the social and political impact of disaster management and relief activities on the resilience of local communities.

Spatial Resilience in Social-Ecological Systems: Household-level Distribution of Risk Exposure and Coping Strategies in Eastern Province (Zambia)

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Abstract

Spatial relationships and spatial interactions affect the resilience in social-ecological systems in complex ways. This report reviews relevant literature to demonstrate the utility of a spatial perspective for the analysis of resilience in social-ecological systems, and provides selective examples from preliminary analysis of the extensive household survey in the Eastern Province (Zambia). We employ the term "spatial resilience" to characterize how spatial arrangement, spatial interactions and spatial context relate to the resilience of smallholders to climate variability. We also present a basic framework for transitioning this preliminary work to a more comprehensive analysis of the Eastern and Southern Province study areas.

1. Introduction

Rural livelihoods in many parts of the world are dramatically affected by climate variability and its corresponding impact on water availability and provision of ecosystem services. This is particularly the case in the semi-arid tropics (SAT), which contain 22% of the world's population and high concentrations of chronic poverty and inadequate food consumption (Falkenmark and Rockstrom 2008). Much of the vulnerability of smallholders within the SAT is driven by surface hydrological dynamics; both directly through rainfall variability and indirectly through additional human- or climate-induced land and water degradation. This tight coupling between social-ecological and hydrological systems in the semi-arid tropics make them an ideal setting to conduct fully integrated research between social and physical sciences.

Vulnerability to variations in precipitation is controlled by how meteorological drought propagates into agricultural and ecological drought in SAT landscapes. For example, recent work has shown that in many cases agricultural drought can be quite substantial (i.e. complete crop failure) even when meteorological drought (i.e. rainfall deficit) is mild. Mwale (2003) found that over a period of 22 years the frequency of meteorological drought across 8 agricultural zones in Malawi (defined as annual rainfall equal or less than 1/2 of potential evapotranspiration) was only 1%, but that the probability of low yields was greater than 44%, even in years when rainfall was 80% of potential evapotranspiration. Therefore, the frequency and severity of a "drought year" depends heavily on both social and agricultural factors, which are themselves strongly coupled to spatial expressions of hydrological dynamics, landcover patterns, and local coping behaviors.

When crop yields decline or fail due to insufficient or in some cases excessive precipitation, households adopt various coping strategies to survive, many of which have an explicitly spatial dimension. In a preliminary analysis of a household survey of smallholders conducted in rural Zambia, Lekprichakul (2009) documented various coping strategies employed by households as responses to climate variability and affect on resource availability. These strategies can be categorized as those which are external to the household and those internal to the household. *External coping strategies* are strongly related to the spatial arrangement of environmental resources (land holdings, water) and spatial interactions between households. For example, a household whose upland crops fail during a drought may become a source of labor for other households if they have lowland crops that did not fail. Alternatively, *internal coping mechanisms* include options that do not rely on external forces, such as reducing food consumption or diversifying crops. The decision and option to choose different coping mechanisms depends on a complex set of social and ecological conditions such as the spatial distribution of land holdings, social norms within a community, the spatial distribution of land cover and the availability of food aid.

Here we discuss a basic structure to address the spatial dimensions of coping strategies, and how the choice of external vs. internal coping strategies may be related to the spatial arrangement of households and resources. We present selected examples from the 2007 Resilience Project household survey and close with a description of proposed next steps for analysis.

2. Background

Resilience in social-ecological systems has received a considerable amount of attention in the last 7-10 years (Walker et al. 2002, Walker et al. 2006, Janssen et al. 2007, Anderies, Janssen and Ostrom 2004, Adger et al. 2005), a focus that has developed from earlier work in ecology (Holling 1973) and the hazards and vulnerability assessment literature (Blaikie 1994, Cutter 1996, Dow and Downing 1995, Liverman 1990). Innovative tools such as vulnerability scoping diagrams (Polsky, Neff and Yarnal 2007) and the resilience workbooks for both scientists and practitioners (Resilience Alliance 2007) have offered insight into how to assess vulnerability and resilience which are somewhat elusive concepts that lack consensus definitions (Cutter 1996, Walker et al. 2002). Particular contributions have been made in exploring the social dimensions of vulnerability, including behavioral responses and efforts to identify coupled linkages between social and biophysical dimensions of social-ecological systems (Folke 2006a). New frameworks are also emerging to identify how to decompose complex systems for vulnerability assessments (Turner et al. 2003) and the institutional dynamics that operate in those systems (Ostrom 2007).

Much of this work emphasizing resilience in social-ecological systems has made elegant conceptual arguments and the empirical work to articulate the dynamics in SESs is to some degree catching up with the conceptual foundation. Of course some early literature presented powerful case studies elucidating notions of both vulnerability and resilience, even if those terms were not leveraged at the time of that work. For example, Denevan (1992) demonstrated how smallholders in terraced agricultural system in the Peruvian Andes distributed land holdings in different agro-ecological zones to ensure sufficient crop yields across elevational gradients even in exceptionally cold or dry years.

Resilience research has often emphasized the importance of space and especially cross-scale interactions (Folke 2006b, Walker et al. 2002). And scale-mismatches have been highlighted as a challenge in reconciling management objectives with ecological processes (Borgström et al. 2006, Cumming, Cumming and Redman 2006). This has been demonstrated in watershed level integrated assessment methods and how the scale of climate change analysis must be reconciled with analytical units at the river-basin scale (Yarnal 1998). But while cross-scale interactions are often mentioned as important factors in an analysis of resilience, this work often stops short of a spatial analysis of coupled social-ecological dynamics at the local level. There are exceptions. Carpenter and Cottingham (1997) conducted a novel analysis of landowners around lake systems and the influence of land use on water quality. Ostrom and Nagendra (2006) examined forest condition in protected areas in the context of institutional dynamics through the use of spatially explicit remote sensing analysis. And there are many studies examining spatial characteristics in landscape ecology such as the size of forest fragments in Madagascar and influence on ecological thresholds (Bodin et al. 2006). These are simply examples from the rich literature examining coupled social-ecological systems, but in general there is an opportunity for more specific spatial dynamics (relationships and interactions) to be incorporated into the specific study of resilience because there are relatively few spatially explicit analyses of resilience that have data parity in both the social and biophysical domains.

A spatial analytical perspective to resilience is beginning to emerge. Studies of coral reef systems have demonstrated how reservoirs of biological diversity can buttress regional level resilience of marine populations (Janssen et al. 2006, Nyström and Folke 2001). Spatial interactions between vegetation patches have been found to affect local level dynamics of water flow in arid ecosystems providing insight into the resilience of grassland systems (van de Koppel and Rietkerk 2004). Spatial complexity has been used to elucidate the dynamics between policy and system resilience with regards to fish stocks and lake systems in Wisconsin (Carpenter and Brock 2004). And the concept of spatial arrangement in self-organizing systems has also been explored with specific examples from wetland areas in the US Gulf Coast Plains (Phillips 1999).

Drought prone systems such as the semi-arid tropics provide a powerful location to explore the spatial dynamics of coupled social ecological systems. These systems exhibit strong thresholds when smallholders rely on subsistence crops or market oriented crops that are vulnerable to shortages of available water (Enfors and Gordon 2007). What is of particular importance is an articulation of how resilience is being characterized in a social-ecological system where even small disturbances may cause severe consequences (Adger 2006, Carpenter et al. 2001). For the work proposed here we consider coupled social-ecological dynamics to determine what conditions, particularly the spatial conditions, contribute to the resilience of smallholders in a SAT system. Specifically, we seek to address when smallholders expend their portfolio of coping options to deal with food and income shortages thus moving into a condition of food deficit. We by no means are decoupling social and biophysical dynamics, but we are particularly focused on the spatial dynamics of coping strategies by smallholders in the context of these coupled systems.

These are systems where even small disturbances may cause severe consequences for human livelihoods (Adger 2006). The heterogeneity of water availability can result in substantial differences in vegetation productivity within local areas leading to complex dynamics at the community level. In these contexts community dynamics can play a powerful role in how natural resources are managed (Agrawal and Gibson 1999). Such an arrangement suggests the opportunity for the interplay between household level decision-making and community level institutions to be explored in resource limiting environments (Adger 2000, Agrawal and Gibson 1999, Tobin 1999).

The frequent occurrence of agricultural and ecological droughts even under conditions of adequate rainfall is a common occurrence in semi-arid agro-ecosystems across sub-Saharan African (Rockstrom and Falkenmark 2000). One reason for this apparent de-coupling between climate and vegetation productivity in agricultural settings is the fact that crops in typical smallholder farms use only 20-30% of available soil moisture, with much of the rest being lost to soil evaporation (Rockstrom, Barron and Fox 2003). In general, past approaches to understanding agro-ecosystem vulnerability to rainfall variability have focused on rainfall totals and crop water deficits defined at seasonal scales. However, many semi-arid agro-ecosystems experience only a few dozen rainfall days, and in some cases up to 80% of the seasonal rainfall totals arrive in 1 or 2 storms. Therefore, the characteristics of storm arrivals and storm depths, and the responses of crops to individual rainfall events (and subsequent soil moisture dry down) is crucial to assessing the overall productivity of semi-arid agro-ecosystems. In addition to being subject to enormous variability in spatio-temporal rainfall patterns, SAT agro-ecosystems also present an additional challenge in defining relationships between soil moisture dynamics and instantaneous rates of crop/plant production: the difficulty in obtaining accurate estimates of plant water use in areas where bare soil evaporation contributes greatly to total evapotranspiration. Therefore, predicting the response of SAT ecosystems to intra- and inter-annual variations in rainfall is greatly complicated by the fact that vegetation structural pattern and fractional cover strongly impact surface evaporation and transpiration partitioning. For example, trees and crops strongly modify both the light and moisture environment underneath their canopies, with significant consequences on grass production and efficiency as well as soil evaporation rates (Caylor et al. 2004). Because of differences in ET partitioning it is likely that a dispersed-tree savanna of similar biomass and leaf area will have a different response to climate forcing than a clumped-tree or leopard-spot savanna with respect to productivity, vegetation water use, and atmospheric coupling. These same issues arise in SAT agricultural landscapes, where E/T partitioning can be critical to success or failure of wet season crops.

The above discussion highlights two issues that are central to progress in assessing the resilience and productivity of dryland agro-ecosystems: (1) the development of coupled hydrological/ecological modeling approaches that emphasize a more temporally resolved and dynamic perspective of crop-soil-water interactions, and (2) a more refined characterization of dryland water balance in agro-ecosystems, particularly partitioning total evapotranspiration between plant water use (transpiration) and soil evaporation. Because of the pronounced physiological and ecological divergence between trees, grasses, and crops, mixed-use tropical water-limited agro-ecosystems are particularly appropriate for coupled ecological and hydrological analyses that seek to relate stochastic rainfall and subsequent soil moisture dynamics to both plant water use (D'Odorico and Porporato 2006, Rodriguez-Iturbe et al. 1999) and vegetation productivity (Scanlon et al. 2007). However, these approaches have primarily focused on natural savanna and woodland landscapes and have only rarely been applied in agricultural contexts (see (Sambatti and Caylor 2007) as one exception). In contrast to the availability of general theories and frameworks for coupling plants and soil moisture in heterogeneous, stochastic dryland ecosystems, there is a general lack of landscape-scale measurements of evapotranspiration partitioning in any dryland landscapes, and in particular dryland agriculture. The availability of more refined and direct observations of E/T partitioning and crop performance will allow us to make more substantial and transformative contributions to the social-ecological resilience of semi-arid tropical dryland communities.

3. Framework for Analysis of Spatial Resilience in Social-Ecological Systems

For this work, we employ the term “spatial resilience” to refer to the influence that the spatial arrangement of resources and the spatial interactions in a coupled social-ecological system have on the resilience of that system. We acknowledge this is not the first use of this term. Spatial resilience has been used to explain how spatial interactions in coral reef systems maintain healthy ecosystems over time and across spatial scales (Nyström and Folke 2001). Spatial interactions and resilience have also been used to explore vegetation dynamics in arid ecosystems (Scanlon and Sahu 2008, van de Koppel and Rietkerk 2004), but this is work that has not incorporated social dynamics. Much of the earlier literature on the resilience of social-ecological systems emphasizes the role of spatial dynamics (Walker et al. 2002). But this work is mostly conceptual (Janssen et al. 2007), or does not incorporate explicit spatial analysis of empirical data of both social and ecological dynamics (Carpenter and Brock 2004, Nyström and Folke 2001).

Here we propose an examination of resilience in the context of the spatial distribution of social and ecological resources and the spatial interactions across social and biophysical domains. In Figure 1 we present a conceptual diagram outlining how the different domains can interact through spatial expressions of resource distributions. We emphasize the internal vs. external coping mechanisms because of the role that spatial relationships play in the option and choice of external coping mechanisms. In the following section we describe spatial characteristics that govern these spatial dimensions of resilience and selective examples as a foundation for future analysis.

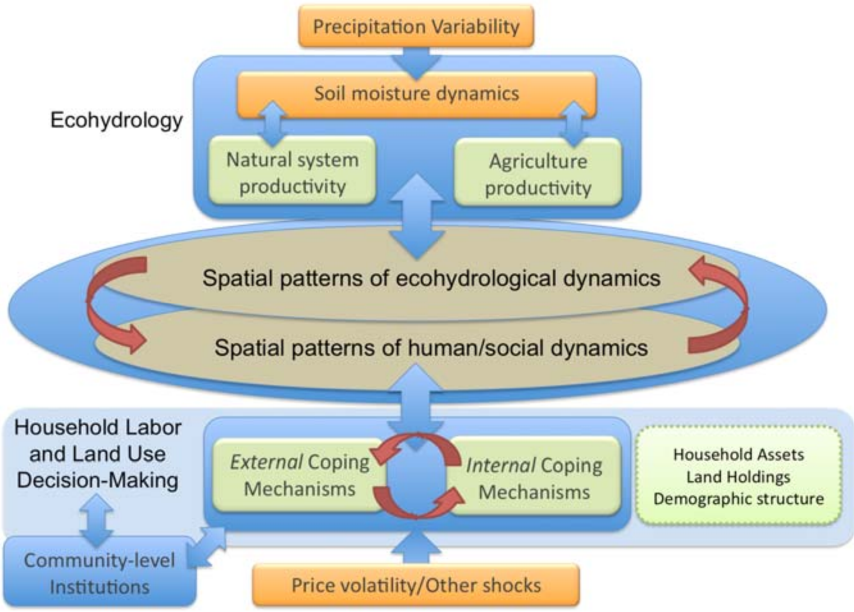

Figure 1. Spatial Resilience in Coupled Social-Ecological Systems of SAT

3.1 Spatial context and social-ecological systems

In this section we describe some spatial domains that relate to the dynamics of social-ecological systems and present preliminary descriptive results from the 2007 Resilience Project extensive survey data conducted in the Southern and Eastern Provinces. One of the most fundamental spatial issues mentioned in the SES literature is the role that spatial scale plays in both social and ecological processes (Cumming et al. 2006, Peterson, Allen and Holling 1998, Walker et al. 2002, Walsh et al. 1999). First, from a measurement perspective, the relationship between social and biophysical processes has widely been acknowledge to have scale dependent properties (Walsh et al. 1999). Likewise, simulation models also exhibit scale dependence as a function of the operational resolution and cross-scale dynamics (Evans and Kelley 2004). Lastly, institutional literature has noted the role that institutions at multiple levels (e.g. federal, state, community) play in the management of resources expressed through the concept of polycentricity (Davoudi 2003, Evans, York and Ostrom 2008). Thus, the spatial resilience of social-ecological systems in part is affected by the cross-scale dynamics affecting that system.

From a more spatial analytic perspective, concepts of pattern and process from landscape ecology have long been shown to affect the dynamics of natural systems and coupled natural-human systems (Forman 1995). Spatial metrics including measures of spatial pattern, spatial arrangement and spatial composition can be used as indicators of system function. For example, we can expect that a community that is 90% forested will have a different degree of reliance on forest resources than a community that is 5% forested (e.g. spatial composition). In addition, the spatial *distribution* of resources can be important. Assuming a community has 20% forest cover, the ecological characteristics of that forest will differ depending on whether that forest cover is spread across dozens of < 1 ha patches, or in a single 40 ha patch. Lastly, the spatial arrangement of resources can be critical to the accessibility of resources. A household whose fields are within 100 m of a water source will have different capacity to irrigate fields than a household whose fields are 1 km from a water source. And as a final example, local level topographic heterogeneity is strongly associated with crop diversification as smallholders seek to develop a portfolio of crop types in areas of varying soil moisture to mitigate against extremes in seasonal precipitation.

3.2 Preliminary examples from 2007 extensive household survey

These are merely simple examples to emphasize the role that spatial context can play in social ecological systems. To measure the influence of these spatial dynamics requires a research design that includes the collection of spatially explicit data. The 2007 Resilience Project extensive household survey data collected the spatial coordinate of household locations. Several coding errors and inconsistencies were found in the data and these were corrected during the summer of 2008. Household locations were then plotted for the Eastern Province observations for exploratory spatial data analysis of exposure to shocks and coping strategies. Data collection for the 2007 survey was focused on the 2005/2006 cropping season, and respondents were asked what disturbances/shocks they experienced in the preceding 6 years, and what coping strategies they employed in the 2005/2006 cropping season. The spatial distribution of surveyed households was organized by clusters of 15-20 households within individual Standard Enumeration Areas (SEA). The survey consisted of 1008 completed surveys, 552 from the Eastern Province SEAs and 456 from the Southern Province SEAs. Each SEA may contain up to several hundred households so the degree to which the surveyed households adequately represent individual SEAs varies across locations. The spatial data consist of the location of the household residence as it was prohibitive to collect field boundaries or locations for such a large number of observations. Still, it is possible to conduct a preliminary spatial exploration of the household data based on key variables to identify general trends and relationships in the data.

The following preliminary results will focus on the Eastern Province observations which were clustered in a subset of 5 districts and 21 SEAs, primarily in the south-central region of the province. Figure 3 shows the spatial distribution of households that reported they were affected by flooding in the preceding 6 cropping seasons. Households in the southern portion of the sampled area reported less exposure to flooding than households in the northern portion of the sampled area. This may be a product of the general regional trend in precipitation, or it could be a function of local level heterogeneity of soil moisture and topography. Future spatial analysis of digital elevation data will be used to explore this further. Figure 4 presents the corresponding reported exposure to drought. Clearly, more households reported they were affected by drought than flooding. Also, households reporting they were affected by drought are more widely distributed and less clustered than the households reporting exposure to flooding. The spatial heterogeneity of exposure to drought suggests several possibilities for subsequent analysis with respect to resilience. In local areas where a greater proportion of households report exposure to drought, vulnerable households have fewer coping options if other proximal households were similarly affected. In contrast, in areas where only a small number of households exhibit exposure then there may be more coping options such as providing labor for other households.

Spatial cluster analysis may misrepresent these relationships in areas of high population density because the sampled households may not be representative of local populations. However, a next step for analysis is a qualified preliminary analysis of the heterogeneity of exposure.

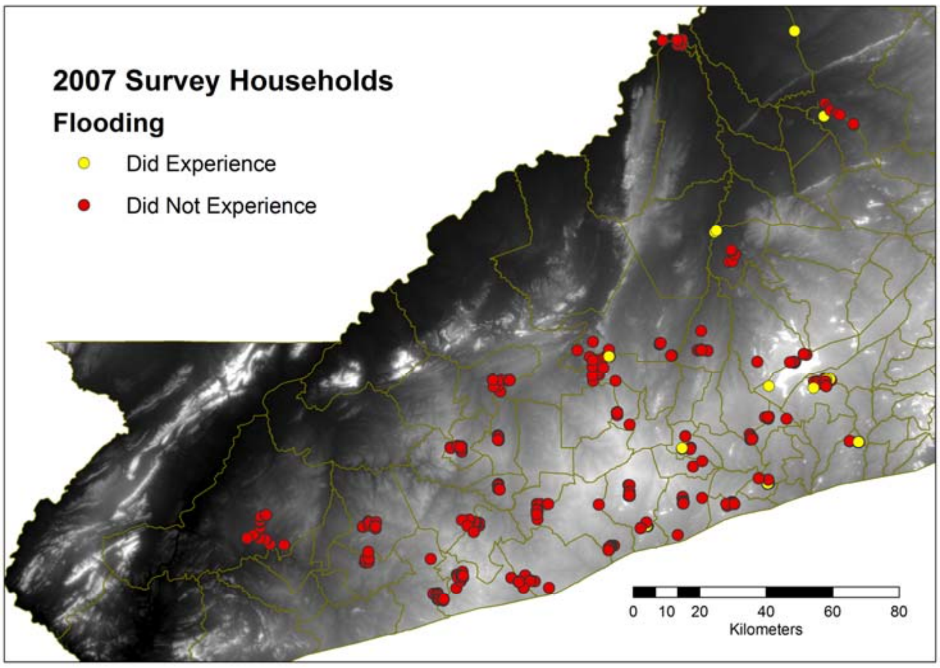

Figure 2. Spatial distribution of households reporting flooding, Eastern Province

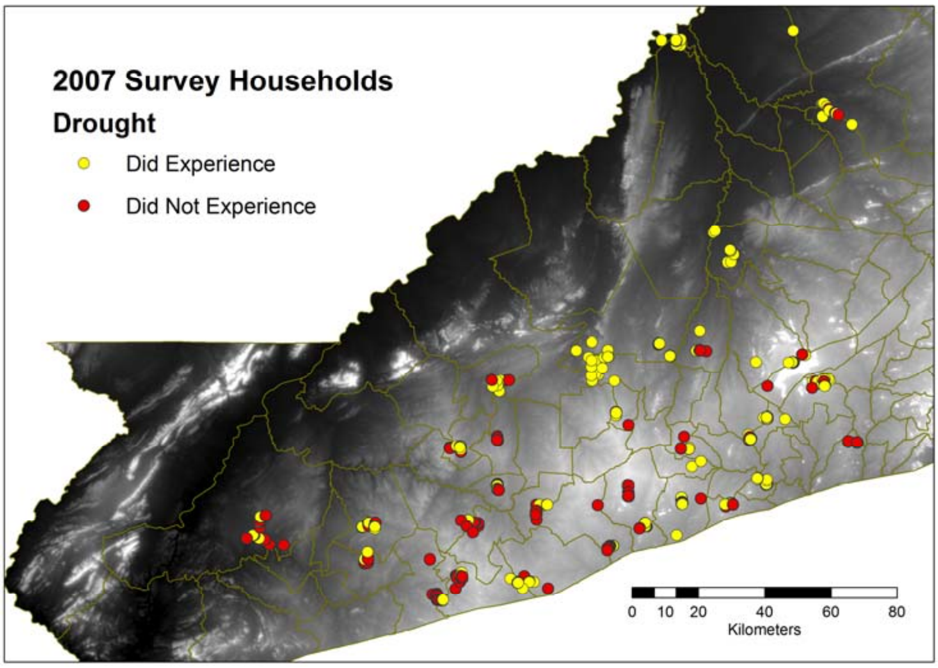

Figure 3. Spatial distribution of households reporting drought, Eastern Province

For those households reporting exposure to drought or floods, we can then explore the spatial distribution of the coping strategies employed. Coping strategies were categorized as internal vs. external strategies to explore how local-level spatial interactions relate to the coping strategy alternatives. Examples of external coping strategies include piecework for other households in the village, piecework for households in other villages or relying on food aid. Internal coping strategies including reducing the number of meals, pulling children out of school to increase labor supply or diversifying crops. Figures 4 and 5 present the spatial distribution of households coping strategies. In figure 4 a majority of the responses are null in the southern area because these households did not report exposure to drought. Figure 5 shows a wide variety of coping strategies with both internal and external strategies evident in different areas.

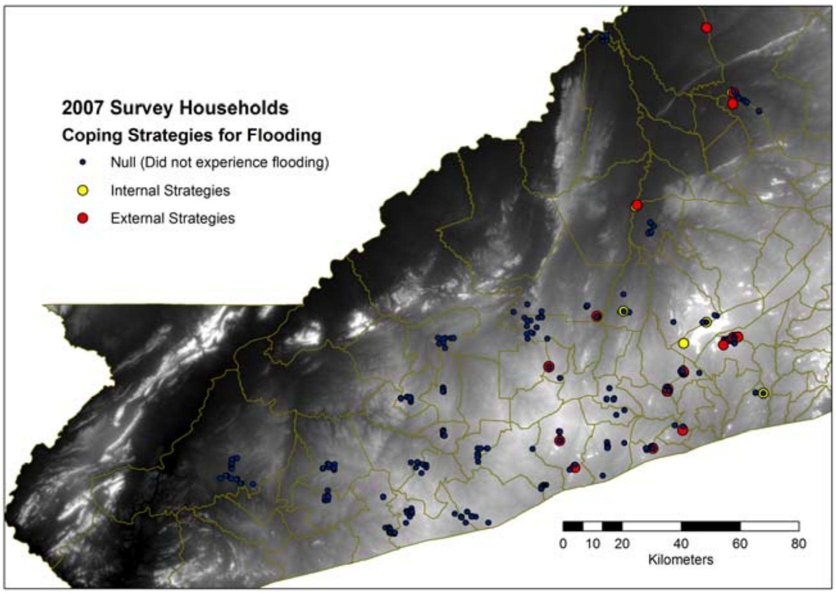

Figure 4. Internal vs. external coping strategies of households reporting flooding, Eastern Province

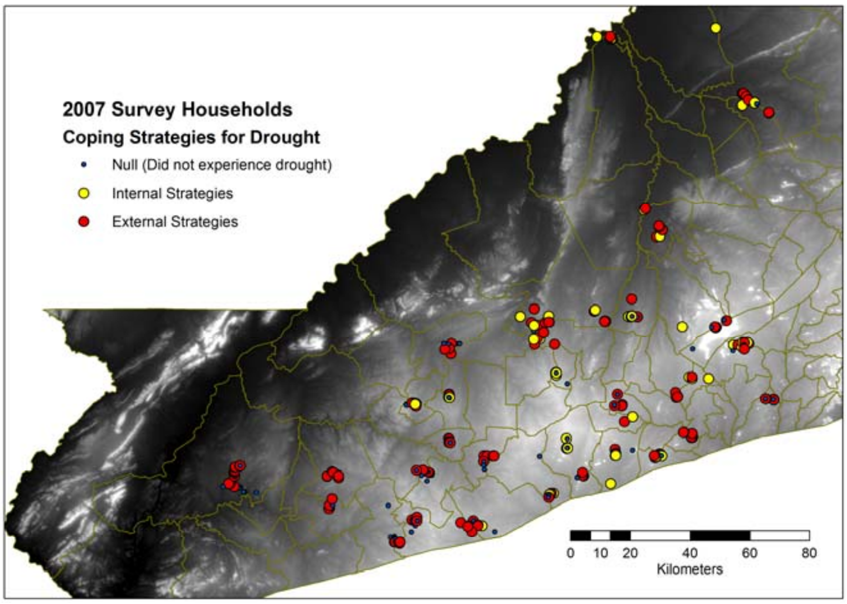

Figure 5. Internal vs. external coping strategies of households reporting drought, Eastern Province

Exposure to drought and flooding is in part a product of the number of land holdings and crop diversification. Figure 6 shows the number of crops planted by household for the 2005/2006 cropping season. There are a large number of households that report planting only a single crop. There is also considerable heterogeneity within local areas with some households reporting 4-6 crops planted in the same areas where other households report planting only one crop. This heterogeneity of crop diversification presents a key question for subsequent analysis. Previous research has demonstrated how in some cases households choose crop diversification over maximizing yields or returns to mitigate against precipitation variability. But this analysis has been conducted at the household level. An unresolved question is the role of household interactions in community level resilience. In other words, households choosing to plant only one crop may not have inherently more risk exposure if they have the option to rely on other households if their crops fail. In this scenario, households may have greater exposure to crop failure, but not necessarily less resilience to climate variability. This is an additional area for future analysis. Again, the extensive survey data use a spatial sampling design that limits the ability to fully characterize the spatial interactions between households. Still, the spatial clustering of exposure, coping and crop diversification can be performed while attempting to control for households that are not part of the survey.

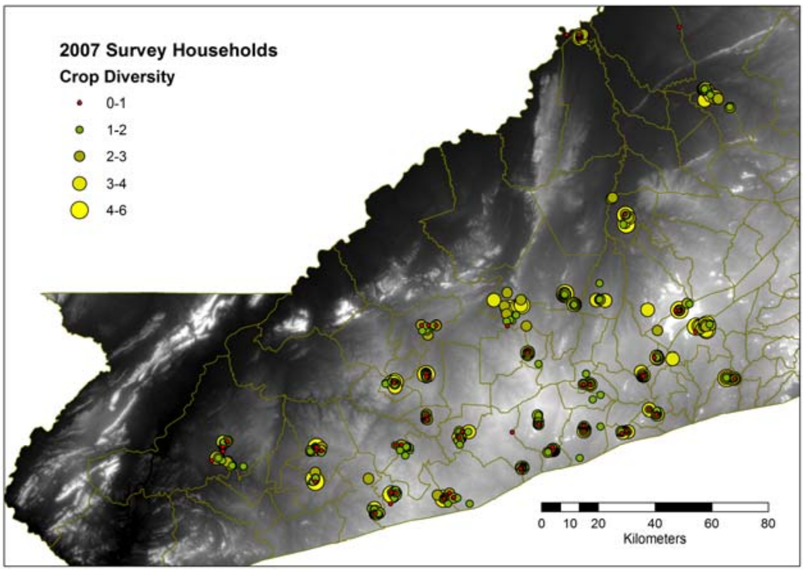

Figure 6. Spatial distribution of crop diversification, Eastern Province

4. Future Work

This report has presented a basic conceptual framework for an analysis of spatial resilience and suggestions for future analysis of the 2007 extensive household survey data. We hypothesize that these climate- and landscape-dependent relationships lead to the development of differential coping strategies in response to climate variability. We also suggest that households develop complex portfolios of coping strategies that are related to the spatial arrangement of resources, but that different households faced with the same shocks may choose different coping strategies depending on their household assets or previous experience. In future work we plan to assess both household level dynamics (land use and labor allocation) and land suitability in a spatially explicit framework to identify the contribution of spatial configuration and spatial interactions in the resilience of smallholders.

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Child Growth as a Measure of Household Resilience:

A Re-Examination of Child Nutrition Situation Using New Growth Reference Standard

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Abstract

The paper examines child health and nutrition status under a frame work of social-ecological resilience. It is argued that nutrition indicators can be used as a measure of household resilience because the indicators, i.e. stunting, wasting, and underweight, are closely linked to household available resources which determine household capacity to recover from shocks. We use data from Living Condition Monitoring Survey which is a nationally representative survey of various years to examine nutritional status and trends of children under-five years old. Our anthropometric indicators are estimated based on the WHO multi-growth center of 2006. We contrast our results to CSO estimates that are based on the NCHS 1978 child growth standard. It is found that the WHO standard yields higher prevalences of stunting and wasting because the reference children are taller than those in the NCHS 1978. The underweight prevalence of the WHO reference, on the other hand, are lower than one based on the NCHS since the WHO children are relatively lighter.

Nutrition status of Zambian pre-school children is characterized by very high prevalence of stunting coupled with low prevalence of wasting and moderate level of underweight. Overtime, under-nutrition situations have shown signs of gradual improvement. Although there are signs of gradual improvements, nutritional situation in Zambia has not categorically changed since 1991. The nutritional pattern as defined by WHO threshold classification was and still is characterized by low prevalence of acute malnutrition and critically high prevalence of chronic malnutrition. However, changes in intensity of degree of seriousness are occurring in opposite directions. While the acute malnutrition that brings death to children is approaching a natural level observed in reference populations, the chronic malnutrition that causes impaired physical and intellectual development has grown more severe than what it was at the start of the economic adjustment program in 1991. With half of children malnourished, a nutritional security situation of Zambian children is in a precarious position. The under-fives are on the edge of falling into a full scale nutrition crisis when a large scale shock either from social or ecological environments hits the economy.

Introduction

Zambia is a country in a semi-arid region. The economy is largely a resource base. Minerals, e.g., copper, cobalt, lead, zinc and agricultural products, e.g., sugar, cut flowers, tobacco, vegetables and cotton are Zambia's primary source of foreign earnings. Four out of five usually working populations are in agricultural sector that comprises largely of small-scale rainfed farmers. Climate variability, therefore, poses a substantial common risk to the livelihoods of Zambia economy. Since 1990, Zambian farmers have experienced several agricultural droughts and occasional floods in recent years. A major continental-wise drought occurred in 1992/93 agricultural season and caused serious crop damages; maize yield was at merely 40 percent of the normal level under good weather conditions (Lekprichakul 2008).

In an uncertain environment, households need to build resilience to income or consumption shocks. Here, resilience is defined as a household capacity to recover from negative shocks. The household's recovery capacity depends on households' available resources which can be categorized into five distinct capitals: i.e., human, social, natural, physical and financial capitals (Sakurai 2006). Assessing household resilience by directly measuring all five categories of capitals can be impractical especially for social capital. Alternatively, one can assess household resilience from outcome variables that reflects resource availability on child growth. Here, we focus our attention on three common nutrition indicators: wasting, stunting and underweight. The three indexes and its combination can be used to shed light on timings of food or health deprivations. Wasting indicates a recent episode of consumption short fall or a recent episode illnesses; stunting is a measure of linear growth failure resulted from cumulative energy consumption deficits or chronic illnesses; underweight is a composite indicator of the aforementioned two indices. Our approach to household resilience is similar to ones used to assess food security (FAO 2006), livelihood security (Crooks, Cliggett, and Cole 2007) and human security (UNDP 1994).

Objectives

Objectives of this study are two folds. First, we re-examine stunting, wasting and underweight situation of Zambia preschool children using the new child growth reference standard released by the World Health Organization (WHO) in 2006 and compare that to the official reported figures that are based on the National Center for Health Statistics (NCHS) 1978 growth chart. Different patterns of child under nutrition can have important policy implications on targeting vulnerable groups. Second, we examine child nutritional dynamics to see how malnutrition situation in Zambia has changed over time. Both research questions are expected to shed some light on the household resilience situation in Zambia overtime.

Designs and Settings

Data used in this study are from a series of Living Condition Monitoring Surveys (LCMS) which are nationally representative surveys conducted by the Central Statistical Office (CSO) of Zambia. The surveys are conducted every two years with some exceptions. Currently available data cover a period from 1991 to 2006, a total of seven survey years, i.e. 1991, 1993, 1996, 1998, 2002, 2004 and 2006. Each year of data contains a sample of no less than 5,000 pre-school children with complete and valid anthropometric measurements. Sex ratio of our samples is approximately equal. Child height and weight are measured by trained enumerators using standard measurement protocol. The height of child under 24 months is measured in length. A child age less than 3 months old are excluded from measurements.

Methods

We use standard definitions to classify child nutritional status as wasted, stunted and underweight. A child with weight-for-age z-score (WAZ), height-for-age z-score (HAZ) and weight-for-height z-score (WHZ) of less than two standard deviations below the mean of the reference children is classified as underweight, stunted, and wasted respectively. When the z-scores are less than -3 SD, the child is considered in severe conditions of the respective classifications. The z-scores based on the WHO 2006 are estimated using WHO's software called IGROWUP for STATA. The classifications based on the NCHS 1978 standard are provided to us by the CSO. Extreme z-scores for each indicator are dropped following the WHO's recommended systems[1]. The classifications are then evaluated descriptively.

Results

Children in the WHO's multicenter growth reference chart are relatively taller but lighter than American children in the NCHS 1978 growth chart (de Onis, Garza et al. 2007). We can expect that the existing CSO published prevalence of stunting and wasting is likely to be underestimated and underweight incidence overestimated.

As expected, our result indicates that the NCHS understates stunting and wasting prevalence, on average, by 11.3 and 4.4 percent respectively (see table 1). The largest relative difference is in the underweight which overstates, on average, by 22.9 percent. Year-to-year differentials of stunting and underweight indices significantly vary and are generally in directions that are expected. The year-to-year variations of wasting differentials between the two standards vary in relatively smaller range and are significant only in 1993, 1996 and 2004. Surprisingly, both standards produce nearly identical prevalences of stunting and wasting in the year 2006. To verify, we examine the means of all three anthropometric measurements. Table 2 clearly shows that the two standards produce quantitatively different standardized scores that are consistent with the expectations, e.g. the |NCHS 1978| < |WHO 2006| for HAZ and WHZ and the |NCHS 1978| > |WHO 2006| for WAZ; all pairs of means of standardized scores are statistically significant differences. The variations of relative differences

[1] A z-score of each indicator is considered an extreme value if it lies outside the following bounds:

- -6 <WAZ<5
- -6<HAZ<6
- -5<WHZ<5

across year might be attributable to non-systematic sampling variations which result in differentials in age composition therein.

Yang and Onis (2008) proposed an algorithm to convert prevalence rates from the NCHS standard to the WHO 2006 growth reference when data for re-estimation of anthropometric indices are not available. In comparison, the proposed conversion algorithm would suggest under/over estimation of 12, 25 and -12 percent for stunting, wasting and underweight respectively (Yang and Onis 2008). The conversion of stunting estimates fit Zambia data, on average, remarkably well but not so with the other two indicators. Poorer fit of the algorithm appears to associate with the body weight component. However, since the prevalence of wasting and underweight of Zambia are at a relatively small base, the differences between the converted and the actual estimates are not likely to be meaningful.

Table 1: Prevalence of Anthropometric Failure of Children under Five by Growth Reference Standards, Zambia[2]

Year	N	WHO 2006			NCHS 1978			Relative Differences		
		Stunting	Wasting	Underweight	Stunting	Wasting	Underweight	Stunting	Wasting	Underweight
1991	5,699	46.1	7.1	18.7	39.6	6.9	22.4	-15.2 ***	-2.7	18.2 ***
1993	6,306	52.5	6.4	20.2	47.1	5.5	24.5	-10.9 ***	-14.8 ***	19.5 ***
1996	7,035	56.0	5.1	18.8	50.1	4.8	22.9	-11.0 ***	-6.7 *	19.5 ***
1998	8,040	57.7	5.3	19.2	50.8	5.3	22.8	-12.7 ***	-0.7	17.3 ***
2002	9,234	51.8	5.3	15.5	43.8	5.3	18.7	-16.8 ***	-1.6	18.4 ***
2004	5,636	55.5	4.7	17.8	49.1	4.2	23.0	-12.3 ***	-10.1 **	25.8 ***
2006	5,868	50.4	5.1	12.8	50.4	5.4	19.5	0.1	5.8	41.6 ***
Average	**6,831**	**52.9**	**5.6**	**17.6**	**47.3**	**5.3**	**22.0**	**-11.3**	**-4.4**	**22.9**

Source: LCMS of various years

Note: Mean differences are statistically significant at < 0.01, < 0.05 and < 0.10 level if denoted by ***, **, * respectively

The relative differences are estimated as ln(NCHS/WHO).

Table 2: Means of Standardized Anthropometric Measurements, LCMS 2006

Z-Score	Mean		Relative Differences
	WHO 2006	NCHS 1978	
Height-for-Age	-2.60	-2.3 **	-11.1
Weight-for-Height	1.72	0.8 ***	-71.6
Weight-for-Age	-0.26	-0.7 ***	104.6

Source: LCMS 2006

[2] It is worth noting that the prevalence of under-nutrition incidence based on the WHO/NCHS standard may differ from the CSO published report. This may be a result of two factors: i.e., (i) using different exclusion criteria, (ii) imposing additional screening criterion of BMI-for-age onto the dataset and (iii) removing records that failed to uniquely match with identifiers in the household roster section.

A long-run average level of stunting over a period of decade and a half showed a persistent growth faltering trend at 52.9% which is very high by WHO classification (WHO 2008). This classification remains qualitatively unchanged when it is compared to the NCHS estimates. For the underweight indicator, opposite is the case. The shift in the standard results in a lower severity classification, i.e., from a severe level of 20% or higher to a moderate level at 17.6%. For the wasting index, the shift in reference standards does not matter. Wasting remains at a low level of prevalence of 5.6 percent.

Table 3: Anthropometric Failures by Asset Quintile, LCMS 2006

Asset Quintile	Overall (< -2 SD)			Severe (< -3 SD)		
	Stunting	Wasting	Underweight	Stunting	Wasting	Underweight
First	54.0	7.1	16.7	33.4	2.6	6.4
Second	59.4	4.8	14.6	38.5	2.4	5.1
Third	49.8	5.3	14.2	32.2	2.7	5.4
Fourth	49.0	4.2	10.4	28.9	1.3	3.5
Fifth	36.3	4.4	6.9	21.3	1.5	1.8

Source: LCMS 2006

Table 3 shows how anthropometric failures vary with resource endowment as measured by assets[3] in 2006. All three nutrition indicators are negatively related to asset level. Although the stunting appears to show some curvature with respect to the asset level, wasting and underweight indictors show clearer linear relationship with asset quintile. Of the lowest asset quintile, wasting prevalence which reflects current energy consumption shortfall is almost twice as high as that of the highest quintile. Higher severity of anthropometric failures (< -3 SD) also shows similar patterns.

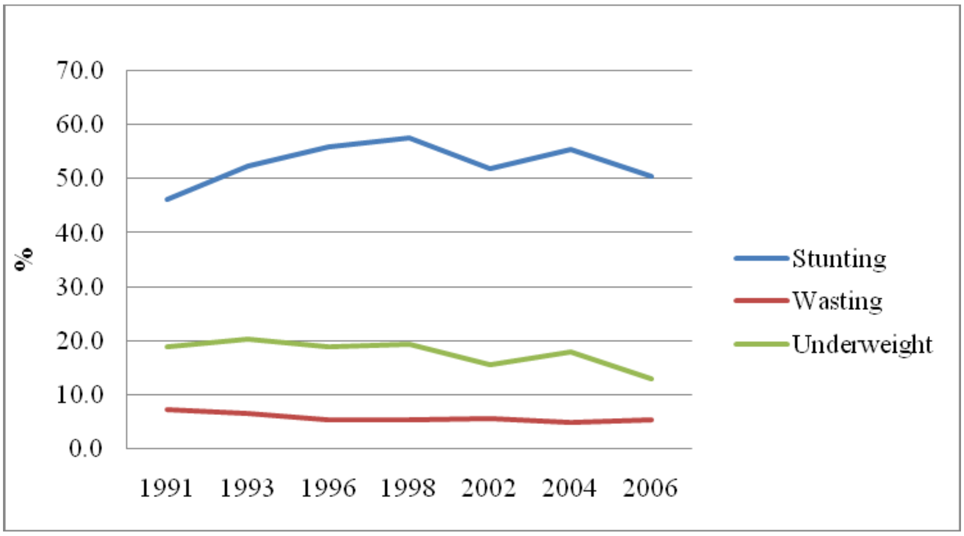
Nutritional Trend

Figure 1 shows trends of anthropometric failures of stunting, wasting and underweight of the under-fives from 1991 to 2006. The underweight situation started off at a relatively high at 18 percent in 1991 and peaked at slightly above 20 percent immediately after the severely drought year in 1993. The underweight situation was at its peak in 1993 which corresponds with a period of deep recession and implementation of the structural adjustment programs as mandated by the IMF and World Bank. However, the trend has gradually fallen since. However, this may not necessarily be a real nutritional and health improvements. The lower wasting prevalence coupled with a rise in stunting prevalence indicates that there may be a shift from acute to chronic form of under-nutrition. The stunting prevalence was at the lowest at 47 percent even after an extended period of deep recession since the

[3] Assets include productive assets, household durable goods, residential buildings, and livestock, a total of 51 items. The asset index is then constructed using principal components and factor analysis.

late 1980s and the launch of market liberalization as well as other structural adjustments required by the IMF to curb with excessive external debt burdens. The situation worsened immediately after a major drought in 1991/1992 agricultural season and continued to rise to reach the peak of 58 percent in 1998 before heading downward to 50 percent which is still higher than the prevalence in 1991.

Figure 1: Trend of Anthropometric Failure of the Under-Five Children, Zambia



Svedberg's Decomposition

Given the relationship that $\frac{W}{A} = \frac{W}{H} \cdot \frac{H}{A}$, stunting, wasting or underweight, on its own, is a partial indicator of undernutrition. Svedberg (2000) proposed an all inclusive framework that will allow disaggregated classifications of under-nutrition and, at the same time, provide all encompassing measurement of total prevalence of under-nutrition. Svedberg's decomposition is derived by combining weight deviation from weight-for-age norm; height deviation from height-for-age norm and deviation from age-specific weight-for-height norm into one single diagram as shown in Figure 2 (see Svedberg, 2000, p.194-195 for details). The framework decomposed population of children that is represented by area of an eclipse into six sub-categories, i.e., a) the well-nourished, b) wasted, c) wasted and underweight, d) stunted, wasted and underweighted, e) stunted and underweight and f) stunted. The total prevalence of under-nutrition can then be measured as:

$$\frac{(1-A)}{A+B+C+D+E+F} = 1-A$$

. Svedberg terms this a comprehensive index of anthropometric failure (CIAF) which is the percentage of children who are non-under-nourished.

Figure 2: Svedberg's Diagram to Measure
Total Prevalence of Anthropometric Failure, LCMS 2006

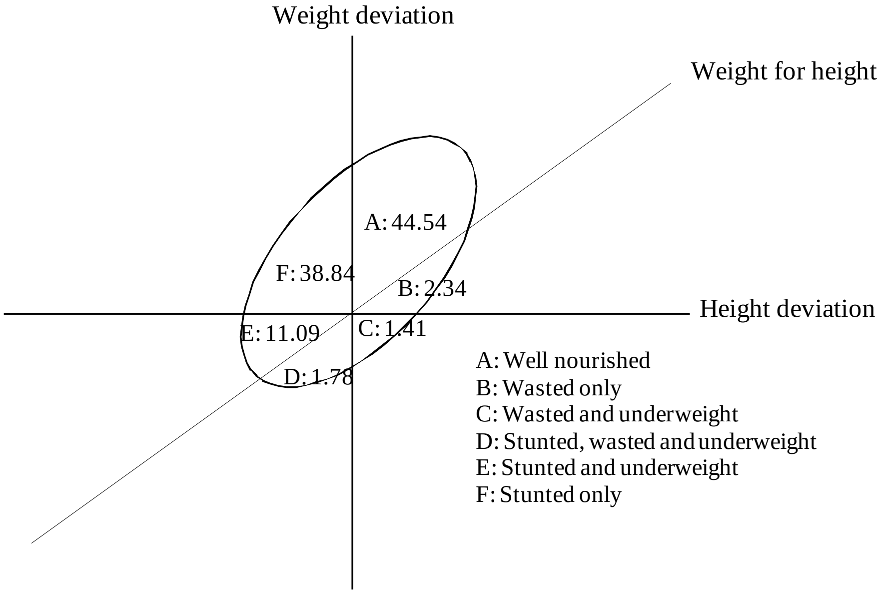


Figure 3 shows a trend of total prevalence of under-nutrition or the comprehensive index of anthropometric failure (CIAF) since 1991. The CIAF was at its lowest level at 51.6 percent in 1991. The index steadily increased thereafter and peaked in 1998 at 61.4 percent. Since then, the overall under-nutrition situation improved but remained high at 55.5 percent in 2006. It is worth noting that the CIAF does not distinguish differences in severity of under-nutrition. The index treats children who fail only one index equally to children who simultaneously fail two or more indices.

To gain further insight into the dynamics of child nutrition, we examine the trend of children who failed all three anthropometric indices: stunting, wasting and underweight (hereafter SWU Index), which corresponds to area *D* in the Svedberg's diagram in figure 2. Figure 4 shows a trend of the under-fives who are simultaneously stunted, wasted and underweight. In general, proportions of children who simultaneously fail all three indices are small, varying in range from 1.5 to less than 3.0 percent. It started off at a relatively high level of 2.1 percent in 1991 after the implementation of market liberalization and other macroeconomic structural adjustment program. The severity of under-nutrition situation peaked in 1993, a combined residual impact of economic recession and a severe drought at the continental scale in 1991/1992 planting season. Since then, the SWU index was on a declining trend and reached its lowest point in the year 2004. There was no evidence of a surge of the SWU in 1998 following an increase in overall prevalence of under-nutrition. Since 2004, there was a rebound in severity of the situation. It is not immediately obvious as to what factors might cause the upswing.

Figure 3: Trend of Composite Index of Anthropometric Failure, Zambia 1991-2006

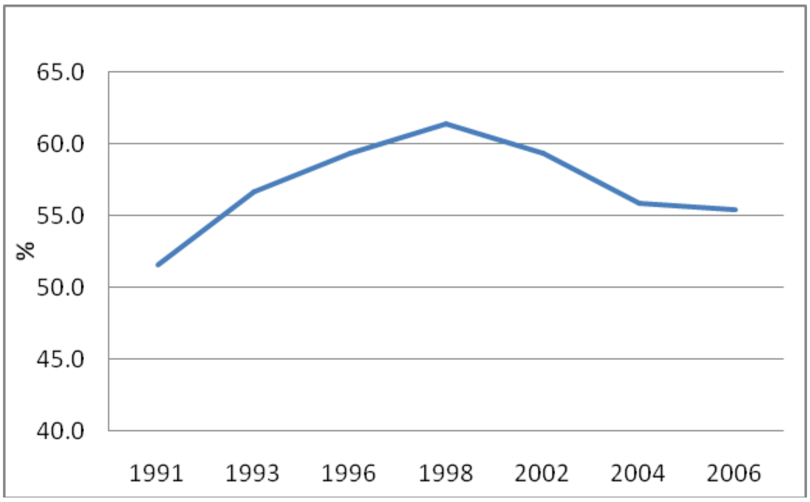
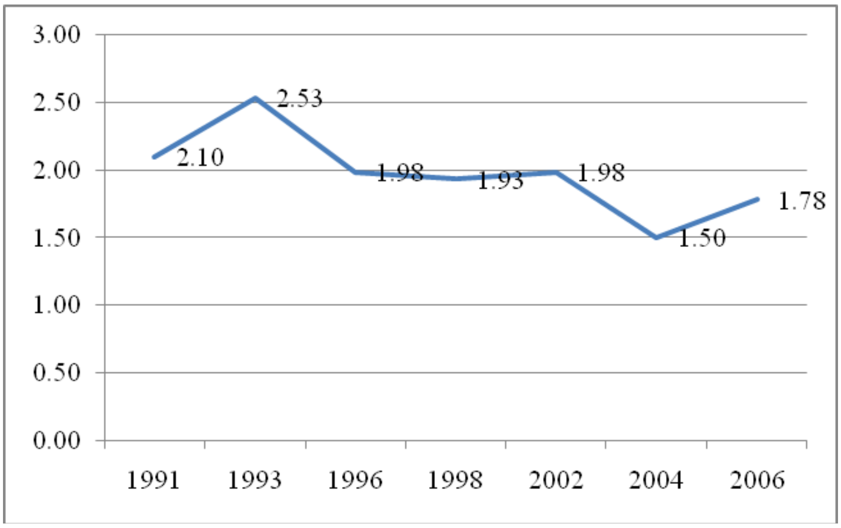
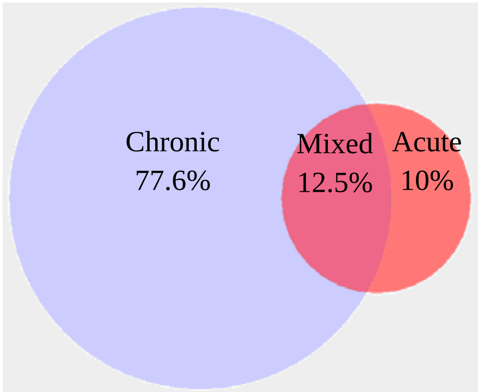


Figure 4: Trend of Under-Fives Simultaneously Failing
Stunt, Waste and Underweight Indicators, Zambia, 1991-2006



Additional benefit of the Svedberg's diagram is its ability to decompose causes of low weight-for-age index into an acute, chronic, and a mixture of acute and chronic under-nutrition. Underweight is defined by the area *C*+*D*+*E* in figure 2. The area *C* is underweight resulting from wasting; area *E* is underweight resulting from stunting; area *D* is underweight from a complex combination of acute cause and chronic nutritional insults. Figure 5 shows that the underweight among the Zambian preschoolers is largely from chronic nutritional insults (77.6 %). Only 10 percent are acutely caused, perhaps, by recent food shortage or recent episodes of illnesses such as malaria, diarrhea or respiratory infections. The remaining 12.5 percent of underweight is a result of a combined effect of acute and chronic under-nutrition. There is a residual of 1.5 percent of an underweight only category whose cause is not identifiable. It is observed that younger age children are more likely to be classified as underweight from acute causes. Older-age children are more likely to be underweight from chronic nutritional insults (table not shown).

Figure 5: Decomposition of Causes of Underweight



Trends in Body Weight and Height

Figure 6-8 show long term trend of mean weight, height and BMI of the under-fives by age group. The under-five children in the most recent survey of 2006 are significantly heavier than those of the 1991 at all age group but the oldest. The rise in average weight comes with surprising shortfalls in mean stature. Compared to those of the same age group in 1991, children in the most recent survey are, on average, relatively and significantly shorter in nearly every age category, which seems to suggest worsening linear growth faltering situation. As a result, mean BMIs of sampled children in 2006 as compared to those in 1991 are significantly higher across all age group except the infant.

Figure 6: Mean Weight of Under-Five Children, SDAPS 1991 vs. LCMS 2006

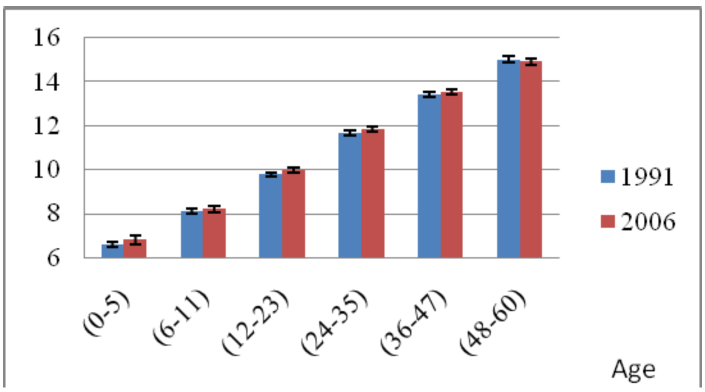


Figure 7: Mean Height of Under-Five Children, SDAPS 1991 vs. LCMS 2006

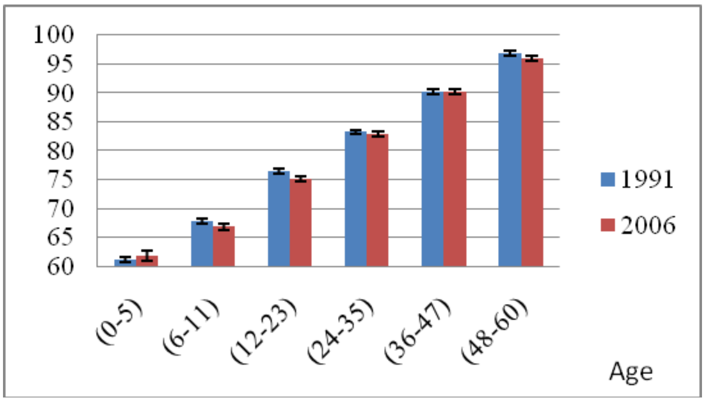
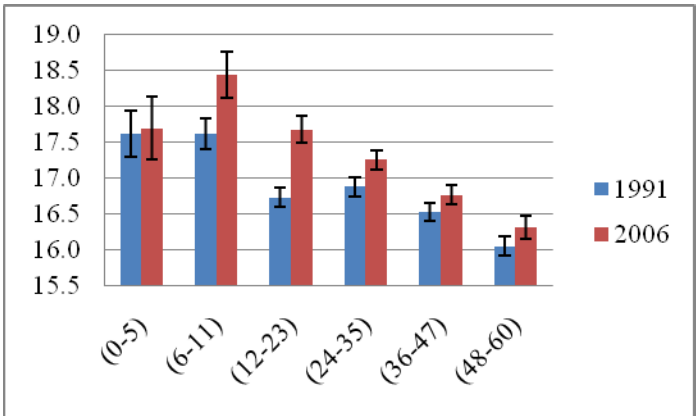


Figure 8: Mean BMI of Under-Five Children, SDAPS 1991 vs. LCMS 2006



What complicate the comparisons are differences in prevalent rates and differences in severity of stunting between the two years in question. To gain further insight, mean weight and height of the stunted and non-stunted children are compared in table 4 and 5. In general, both the stunted and non-stunted children have grown heavier which is consistent with the grand mean of both sub-group combined as indicated in figure 6. For height, evidences clearly suggest that, on average, children are not growing shorter over time as suggested in figure 7. In fact, there are gains in stature overtime among both the stunted and non-stunted, which indicates improving health and nutritional situation. Since weight gains are at faster rates than gains in height, we observed significant increases in BMI among children with and without linear growth falters.

Table 4: Mean Weight and Height of the Under-Fives by Age Group, Zambia, 1991-2006

Age	Weight: Stunted		Weight: Non-Stunted		Height: Stunted		Height: Non-Stunted	
	1991	2006	1991	2006	1991	2006	1991	2006
(0-5)	6.2	5.7 *	6.7	7.1 *	56.7	55.1 *	62.7	63.9 *
(6-11)	7.4	7.8 *	8.4	8.5	62.8	62.6	70.6	69.9 *
(12-23)	9.0	9.4 *	10.3	10.6 *	71.5	71.1	79.7	79.9
(24-35)	10.9	11.1	12.3	12.8 *	78.1	78.5	87.7	88.6 *
(36-47)	12.3	12.7 *	14.3	14.5 *	84.3	84.8 *	95.1	96.4 *
(48-60)	13.9	14.1 *	15.9	15.7	90.4	90.5	101.6	101.5

Note: * indicates statistically significant at 0.05 levels.

Table 5: Mean BMI of the Under-Fives by Age Group, Zambia, 1991-2006

Age	BMI: Stunted		BMI: Non-Stunted	
	1991	2006	1991	2006
(0-5)	19.2	18.6	17.1	17.4
(6-11)	18.9	20.1 *	16.9	17.3 *
(12-23)	17.6	18.6 *	16.2	16.6 *
(24-35)	17.9	18.0	16.0	16.3 *
(36-47)	17.4	17.7 *	15.8	15.7
(48-60)	17.0	17.3 *	15.4	15.3

Note: * indicates statistically significant at 0.05 levels.

Discussion and Conclusion

The research views child health and nutrition issues under a perspective of social resilience. A society with a chronically high level of child malnutrition is vulnerable to natural and economic shocks that can easily trip the child nutritional situation into a crisis level. The UNICEF has long labeled this issue a silent emergency (UNICEF 1998) despite the loud cries of hungry children. In nearly two decades, very little progress has been made to combat malnutrition among Zambian preschoolers. From the 1991 to the 2006 survey, stunting actually increased by 11 percent; wasting and underweight dropped by 20 percent. However, the level of stunting remains critically high; underweight improves from high to a moderate level; and wasting is approaching acceptable level. The low height-for-age together with weight-for-height just slightly below that of the reference population is a typical pattern observed in eastern and southern Africa (UNICEF 2007)

In comparison to the NCHS 1978 growth standard, the new WHO 2006 growth reference yields significant differences in nutritional classifications of a population. Prevalence rate of stunting and wasting tends to be higher but the underweight rate tends to be lower[4]. The new standard not only changes the level estimates but it also alters the distribution of malnutrition children across age group. Significant changes in the distribution of under-nutrition occur at the age below 24 months. The most

[4] By extension, overweight prevalence based on the new standard will be higher.

pronounced divergences are at the age of 6 months or younger. These empirical findings are consistent with past comparative studies (de Onis et al. 2006; de Onis et al. 2007).

Conceptually, the WHO growth reference standard for infants and young children is superior to the NCHS growth standard in many fundamental ways. The latter is based on a descriptive approach that describes how American children *actually* grew in 1970s and the former is based on prescriptive approach that describes how the children *should* grow under recommended health practices. These ideal health behaviors include breastfeeding, non-smoking during pre- and post-pregnancy, and sound nutritional and health care practices to minimize restrictions to growth potential. The new standard is international in that it derives from the growth of carefully selected children from six countries, i.e. Brazil, Ghana, Oman, India, Norway and the United States, to represent various parts of the world. A significant improvement of the new growth curve is among children aged 0-23 months for the growth chart was derived from a longitudinal study. The NCHS, on the other hand, is based on cross-sectional data across all age groups. The NCHS growth standard's poorest accuracy is among the infants aged 0-6 months where there were thin observations and the growth curve was basically derived from a mathematical smoothing function (Greer 2008).

Beside the difference in population, methodology used is the other critical difference that distinguishes the WHO standard from the NCHS 1978. While the WHO 2006 utilizes LMS method to address the skewness of the data so as to generate fitted curve that closely follow the empirical growth, the NCHS 1978 did not. The CDC 2000 growth standard employs LMS methodology to improve upon the NCHS 1978. The failure to address the skewness together with a transition from recumbent length to height measurement at age 24 months may have explained the observed spikes of stunting, wasting and underweight at the 12-23 month age group.

Under-nutrition situations of the Zambian preschoolers have shown signs of gradual improvement. Stunting and non-stunting children alike are all growing taller and heavier. Rising per capita income and improved public health services may have contributed to the overall development.

Categorically, nutritional situation in Zambia has not changed since 1991. The nutritional pattern as defined by WHO threshold classification (WHO 2000) was and still is characterized by low prevalence of acute malnutrition and critically high prevalence of chronic malnutrition. However, changes in intensity of degree of seriousness are occurring in opposite directions. While the acute malnutrition that brings death to children is approaching a natural level observed in reference populations, the chronic malnutrition that causes impaired physical and intellectual development has grown more severe than what it was at the start of the economic adjustment program in 1991. Does this mean that food intake is lacking micronutrients that promote linear growth? Perhaps, the answer might be no. A biochemical and parasitic investigations of stunting children in Samfya District, Luapula province, Zambia found that children with linear growth retardation had normal level of zinc and other linear growth promoting biochemical (Hautvast et al. 2000). Similarly, Friis et al. (1997) found stunting children in a neighboring country of Zimbabwe stopped responding to zinc supplement after a period of three months, which implied an existence of other linear growth limiting factors. Hautvast et al. hinted at high prevalence and recurring malaria insults and inadequate caloric intake as more likely causes of severe stunting among Zambian under-fives. Whether these findings are generalizable to other provinces of Zambia requires further study.

With half of children malnourished, a nutritional security situation of Zambian children is in a precarious position. Zambian preschool children are on the edge of falling into a full scale nutrition crisis when a large scale shock either from social or ecological environments hits the economy. Since stunting children may appear small but healthy, there is usually no immediate public pressure for the government to act. With a recognition that investments in education and economic development will not be effective unless undernutrition among small children is significantly reduced (Gross and Webb 2006; Ruel and Hoddinott 2008), the World Bank argued that reducing malnutrition is a key to reduce poverty (Gillespie, McLachlan, and Shrimpton 2003).

Halving prevalence of undernutrition by 2015 was included as one of the target parameters in the first Millennium Development Goal (MDG) of halving extreme poverty by the end of 2015. Assuming that Zambia were able to sustain an annual reduction of undernutrition by 1.2 percent, which was observed in the composite index of anthropometric failure (CIAF) from 1998 to 2006, the CIAF will reach its half of 27.5 percent by the year 2062, approximately 47 years behind the target! To achieve the MDG goal, government needs to increase their efforts by at least five folds assuming linear relationship of government efforts and reduction of CIAF. The International Food Policy Research Institute (IFPRI) recommended emphasis on preventing undernutrition by targeting optimal intervention time which is during pregnancy to age 2 years (Ruel and Hoddinott 2008).

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Impact of Tsunami on the Farm Households of Coastal Tamilnadu State, India*

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Abstract

Tsunami attacked the Indian coast on 26th December 2004 and the worst affected areas along the Indian coast were in Tamil Nadu, Kerala, and Andhra Pradesh states. Tamil Nadu state suffered maximum loss with the damage concentrated in four districts. A study was conducted in Nagapattinam district of Tamil Nadu State, India during 2005-08 with a sample of 240 households. Results had indicated that about 77 per cent of the households were with farming before tsunami and it has reduced to 25-37 percent after tsunami. In the non-farm sector, 10 per cent of the households were involved in non farm activities before tsunami and this has increased to 24 – 38 per cent after tsunami. The percent distribution of labour households is about 50 percent after tsunami compared to only 11 percent before tsunami. The overall mean technical efficiency is around 83 percent indicating the scope for increasing the technical efficiency further by 17 percent. The results of the soil and water analysis further indicated that the agricultural environment of the district recovered rapidly after the tsunami. Paddy is the major crop in the region and the profit was ranging from Rs 3695/ha in 2006 to Rs 6405/ha in 2007 compared to adjacent non-tsunami regions which was ranging from Rs 5600 to Rs 8500 /ha confirming the coastal risks in paddy production. Crop management practices and incorporation of crop insurance in agriculture programs are suggested to increase the farm income and minimize the risk in agriculture.

1. Introduction

On 26th December 2004, out of the 7516 km long coastline of India, more than 4500 km stretch was badly affected by the 9.0 magnitude earthquake-triggered tsunami, resulting in the total destruction of living environment along the coast. The worst affected areas along the Indian coast were in Tamil Nadu, Kerala, and Andhra Pradesh states. Tamil Nadu state suffered maximum loss with concentration in 4 districts (Figure 1).

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The paper is a preliminary product of the joint research study undertaken between the Research Institute for Humanity and Nature (RIHN), Kyoto, Japan and Tamilnadu Agricultural University, Coimbatore, India during 2005-2008.

Tamil Nadu is located in the northern hemisphere in the Torrid Zone between 8^0 and 13^0N latitude, and between 78^0 and 80^0E longitude. It is the 11^{th} largest state in India, has a population over 60 million, and occupies an area of about 130,058 km^2. The climate along the coast is warm and humid, and the rainy season is marked by the onset of the northeast monsoon between mid-September and mid- December. Cyclonic storms occur during this period due to depression in the Bay of Bengal (Krishna, 2005).

It was reported that due to 26 December, 2004 Tsunami in Tamil Nadu state, 0.896 million people were affected, 376 villages had heavy damage, 7951 human lives lost, 1000 KM coastal length is affected, the sea water penetrated 1-1.5 KM distance into the main land, 128394 dwelling units affected, 9559 cattle lost, 10245 ha cropped area affected, 42655 boats damaged. (GOI, Ministry of Home Affairs, 09.01.2005). Many felt that impact will be very serious and it will take years to resume normal activities in the region. Keeping this as the base, a collaborative study between Research Institute for Humanity and Nature (RIHN) Kyoto and Tamilnadu Agricultural University, Coimbatore, India was taken up during 2005-2008. This paper presents an analytical study of the impact of tsunami on agricultural production, household income of the farm households on a continuous basis from 2005 to 2008.

The first section describes the review of the tsunami impact studies, the second section deals with the methodology used to collect and analyse the data including the description of the technical efficiency in crop production. The third section deals with the impact of the tsunami on household occupation, and crop production. The results of the technical efficiency analysis in paddy cultivation and brief discussion on the tsunami on soil and water is also made.2. Review of Tsunami impact studies

2. Review of Tsunami impact studies

In The Republic of Maldives, at 9:00 AM (1:00 PM in Japan local time) on 26th December, tsunami attacked this region. Maldives is a group of about 1,200 coral islands, and its maximum height is only 1.8m. Almost all the roads in the capital city Male were flooded. There were no vacancies in hotels because it was Christmas vacation season (time). So, there had happened severe damage by that tsunami. There was no tsunami warning system in the Indian Ocean premises. In some coastal areas, the people could not feel ground motion; so, the inhabitants of that area were suddenly attacked. (Imamura, *et al, 2005*)

The estimated total financial losses in India - as reported by the Government of India - exceed US$1.2 billion. This includes damages to infrastructure, such as roads, bridges, ports and around 154,000 houses. Public buildings, such as schools, Integrated Child Development Services (ICDS) and health centers were equally affected.

Two years after Tsunami people affected by the Tsunami were housed in temporary shelters with basic sanitation, childcare and nutrition services. Some of these people still live in those shelters;

however, the Government has taken up the challenge to rebuild almost 100,000 new homes in all the affected States. As of November 2006, close to 30% of these have been completed. Infrastructure such as water supply, latrines and electricity is being provided in the new sites and destroyed infrastructure like roads and fishing harbours are being rebuilt. At the same time, the livelihoods of fishing communities are being restored and strengthened through a variety of initiatives. Destroyed and damaged schools were rebuilt - some of them received furniture for the first time ever.

Psychosocial and healthcare programmes, aimed at dealing with the immediate physical and mental impact of the Tsunami, were initiated. These are designed to give support on a long term basis. Livelihoods of fishermen were restored with better equipment and programmes were undertaken to increase revenues and offer alternatives to fishing.

During the past year, the recovery work has shifted gradually from immediate needs to long-term recovery. Particular attention was given to the equitable distribution of aid and benefits and to sharing best practices. The establishment of a National Disaster Management Authority has guided the expansion and acceleration of programmes for disaster risk reduction. This has facilitated the move from restoring and delivering services, to strengthening policy and capacity building and the upgrading of infrastructure with the goal to "Build Back Better". (The United Nations, the World Bank and the Asian development Bank, 2006)

3. Methodology and Data Analysis

The study was conducted in Nagapattinam district of Tamil Nadu State, India, which is bounded on the north by Cuddalore district, south by Palk Strait, east by Bay of Bengal and west by Thiruvarur district.

Two hundred and forty respondents from twenty four villages of coastal Nagapattinam district were selected. From 2004 onwards every year upto 2008 (consecutively 4 years) the same respondents were contacted to assess the impact of tsunami on agricultural production, household income of the farm households. Year 2004 represents the year of tsunami and the crop pattern during the period will represent before tsunami situation and the subsequent years will represent the after tsunami situation. Surface soil samples from hundred sites of same farm holding were collected and analyzed to study the changes in the pH and EC from 2004 to 2007 due to the tsunami. The surface water resources meant for irrigation and drinking were affected by the ingress of sea water in all the areas. The massive quantity of sea water that inundated the coastal agricultural lands for 0.5 to 2.0 km area inland, due to reasons of poor drainage, stood for a few days affecting the quality of soil and groundwater. The thicknesses of deposits left in fields were 0.02 to 0.2 m (Chandrasekharan et al. 2005).The electrical conductivity (EC) of soil and shallow groundwater increased by about ten times and 15 times respectively, and the degree of variations differed from place to place. To assess this ten bore holes were drilled in the affected fields. Every month from June 2006 to March 2008 water samples were collected from the bore holes and .the groundwater EC was measured monthly.

The stochastic frontier production function is given by

$$y_i = f\left(x_i;\beta\right)\exp\left(\varepsilon_i\right) \qquad (1)$$

where *i*=1,2,….*n* refers to farms, β is a vector of parameters and ε_i is an error term and the function $f\left(x;\beta\right)$ is called the 'deterministic kernel'. The frontier is also called as 'composed error' model because the error term ε_i is assumed to be the difference of two independent elements,

$$\varepsilon_i = v_i - u_i \qquad (2)$$

where v_i is a two sided error term representing statistical noise such as weather, strikes, luck etc which are beyond the control of the farm and $u_i \geq 0$ is the difference between maximum possible stochastic output (frontier) $f\left(x_i;\beta\right)\exp\left(v_i\right)$ and actual output y_i. Thus u_i represents output oriented technical inefficiency. Thus the error term ε_i has an asymmetric distribution. From (1) and (2), the farm-specific output-oriented technical efficiency is given by

$$TE_i^o = \exp\left(-u_i\right) = y_i \big/ \left\{ f\left(x_i;\beta\right)\exp\left(v_i\right)\right\} \qquad (3)$$

Since $u_i \geq 0$, $0 \leq \exp\left(-u_i\right) \leq 1$ and hence $0 \leq TE_i^o \leq 1$. When $u_i = 0$ the farm's output lies on the frontier and it is 100% efficient. Thus the output oriented technical efficiency tells how much maximum output is possible with the existing usage levels of inputs. It can be shown that

$$E\left(u/\varepsilon\right) = \int uf\left(u/\varepsilon\right)du = \mu_* + \sigma_*\phi\left(-\frac{\mu_*}{\sigma_*}\right)\left[1-\Phi\left(-\frac{\mu_*}{\sigma_*}\right)\right] \qquad (4)$$

and

$$TE_i = \exp\left(-E\left(u_i/\varepsilon_i\right)\right) \qquad (5)$$

where $\sigma_* = \frac{\sigma_u \sigma_v}{\sigma}$ and $\mu_* = -\frac{\varepsilon\sigma_u^2}{\sigma^2}$ and $\phi(.)$ and $\Phi(.)$ are respectively the density function and cumulative density function of the standard normal variate. Formula (4) and (5) are used to compute the technical efficiencies. The Cobb-Douglas functional form was used to estimate the technical efficiencies.

4. Results of the Tsunami Impact Analysis

4.1 Impact of on Household Occupation

It could be observed from Table 1 that before Tsunami (2004), 77 per cent of the respondents involved in farming as agriculture was the predominant occupation in villages. However, after Tsunami it has been drastically reduced to 25 per cent, and it has increased to 37 percent during 2007.

The tsunami had left behind a thick (2 to 20 cm) layer of sea sediments as a slushy black layer over rice fields. The standing crops of rice (*Oryza sativa*) and groundnut (*Arachis hypogea*) in different growth stages were dried up due to induced exosmosis (i.e. the passage of a fluid through a semipermeable membrane toward a solution of lower concentration, especially the passage of water through a cell membrane into the surrounding medium) inflicted severe damage. This impact was felt in crop production during 2005. Further, the flood occurred during October-November 2006 affected the standing crops. This may also one of the reasons for a slow recovery from the tsunami induced shock in the agriculture sector. In addition, agriculture fields near to the coastal areas were affected by sea water intrusion which made the field unfit for cultivation. Many have reported that to avoid risk in farming, they were reluctant to take up farming as a primary occupation.

In the non-farm sector, 10 per cent of the sample households were involved in non farm activities such as small scale fish vending, shell collection and selling, fish net knitting and other similar activities before tsunami and the shift towards non-farm activities had increased after the tsunami, viz., 24, 38 and 20 per cent in 2005, 2006 and 2007 respectively. Later they slowly shifted to their farming activities.

Before tsunami almost 11 per cent of the sample respondents were farm labourers. Subsequently, almost 50 per cent turned to be the farm labourers looking for relief from different agencies. Because of tsunami, many foreign agencies and Indian Government pumped money to the affected areas and to receive the relief packages, many discontinued the agriculture and called them as labourers. Hence, there is a close negative relationship between the number of households in farming and in labour categories.

During 2006, the percentage of farm labourers has reduced to 33 and in 2007 it has been increased to 40 per cent. In addition, few households got employment in the National Rural Employment Guarantee Scheme (NREGS) [1] to sustain their livelihood requirements. This might be another reason for high percentage of respondents in this category. In fishing sector no change in the sample respondents' occupation. Similarly, in the case of unemployment and temple land cultivation, no difference was observed. The chi-square test shows that there was a significant shift from farming to farm labour categories after tsunami (Table 1).

It is also important to see the number of family members involved in farming after tsunami. It could be revealed from Table 2 that after tsunami, involvement of only single family member in

[1] The National Rural Employment Guarantee Act was enacted in September 2005. The National Rural Employment Guarantee Scheme was launched on 02.02.2006 and is being implemented in Nagapattinam district. The National Rural Employment Guarantee Act, 2005 (NREGA) guarantees 100 days of employment in a financial year to any rural household whose adult members are willing to do unskilled manual work. This Act is an important step towards the realization of the right to work. It is also expected to enhance people's livelihoods on a sustained basis, by developing the economic and social infrastructure in rural areas. The Village Panchayat will issue job cards to every registered individual. Payment of the statutory minimum wage and equal wages for men and women are the notable features of the scheme.

farming has increased and reached to 91 per cent. In allied activities (livestock, poultry) and non-farm sector (shop), there is no change in percentage of respondents before and after tsunami.

In all the cases, one member from the family was involved in agriculture and allied activities. Only in the hired work category, more than two family members were involved indicating less importance given to agriculture and allied activities by the households due to tsunami.

4.2 Impact of Tsunami on crop production

Annual normal rainfall of the region is about 1341.7 mm. The North-east monsoon (October to December) contributes about 65% of the total annual rainfall. The South West monsoon (June to September) contributes about 20% of the total annual rainfall. The summer and winter rain accounts for the rest. Normally the cropping season coincides with the North-east monsoon season and if adequate water facility is available, farmers will raise the crop, otherwise the land will be kept fallow. The rainfall pattern shows that in 7 out of 13 Years, the North-east monsoon was deficit and in 5 years, it was surplus thus indicating the climate vulnerability of the region.(Table 3; Figures 2 & 3).

Out of the total geographical area of Nagapattinam district (271583 ha), cropped area accounts for 65.53 percent and 74.5 percent of the agricultural holdings are less than 1 ha. The Forest cover is very minimum accounting for only 1.31 percent of the total area. The district has 10,054 ha of waterlogged lands and 11,047 ha are totally affected by salinity.

Paddy is the main crop of the district and depending upon water availability and other factors, the farmers grow two crops viz., Kuruvai (April to July) and Thaladi (Aug to Nov) or Samba (Aug to Nov) crops. Other cereal crops like Cumbu (*Panicum miliaceum)*, Ragi (*Eleusine coracane),* Cholam (*Sorghum vulgare)*, etc., account for a very small area only. Similarly, some pulses like Red gram (*Cajanus cajan),* Green gram (*Vigna radiata)* and Black gram (*Vigna mungo)* are grown in small area (Statistical Handbook of Tamil Nadu, 2006).

It could be inferred from Table 4, during summer season more than 95 per cent of the respondents had not cultivated annual crops such as paddy (*Orysa sativa)*, cumbu (*Panicum miliaceum)*, ragi (*Eleusine coracane)*, vegetables etc,. in their field in all the years. Only few farmers have grown perennial crops such as coconut (*Cocos nucifera)*, cashew (*Anacardium occidentale)* and mango (*Mangifera indicum)* crops that exists in the summer season.

Regarding Kharif (June- Sep) season crops, based on the availability of water only few farmers (2 %) were able to cultivate paddy during 2004 and 2005 and this also reduced over years (Table 5). However during Rabi (Oct-Jan) season, immediately after tsunami, 20 per cent reduction in paddy cultivation was observed. Drastic reduction in paddy cultivation during October 2006 to January 2007 was due to flood in November 2006 which washed away the standing crops (GoTN, 2006). Cyclonic storm brings havoc normally once in 3 or 4 years and heavy downpour during North-east monsoon leads to flooding of the district and damaged the field crops and wealth of soil. Hence, many farmers had reported that they could come back to normal cultivation during the Kharif season (October 2007 to January 2008) due to flood damages.(Table 6).

Agronomic interventions

Due to tsunami, the sea water intrusion affected the soil and water quality. To overcome this, site specific reclamation strategies like deep ploughing, land smoothening, strengthening field bunds and providing adequate drainage, spreading and incorporation of sand/clay deposits in the field, *in situ* ploughing of green manures like *Sesbania aculeate*, and leaching, wherever required, depending upon soil EC were adopted. To enhance the soil microbial activity, farm yard manure (FYM) at the rate of 5 t/ha and salt tolerant strains of biofertilizers such as phosphobacteria, azospirillum and pseudomonas species at the rate of 2 kg/ha were applied.

In order to see the economics of crop cultivation after tsunami, detailed cost of cultivation was worked out. The cost of cultivation has increased after tsunami due to the above agronomic practices even though the government also provided these inputs at subsidized prices. As indicated earlier, during tsunami year, the standing crop was totally devastated and the year after tsunami, about 70 per cent of the crop had failed due to poor soil quality.

Regarding the cost of cultivation, before tsunami 44 per cent of the paddy cultivating respondents had the expenditure upto Rs.7500/ha. The cost of cultivation of paddy has increased slowly from 2004 to 2007. Before tsunami, 27 per cent of the paddy cultivating respondents had a cost of cultivation of less than Rs.5000/ha and this percentage has reduced in the subsequent years. During 2004, about 28 per cent of the farmers had a cost of cultivation of more than Rs.12000/ha, and it has gradually increased to 44 per cent during 2007 indicating the magnitude of cost increase in crop production (Tables 7 & 8; Figure 4). Among the components of the cost of cultivation, fertilizer and manure accounted for more share, followed by seeds, machine power and human labour.

The average cost of cultivation in 2006 was about Rs 14155/ha and it has increased to Rs 15502 /ha in 2007 (9.5 % increase). About 11 percent farmers were able to get higher income (Rs 21250 to 23750/ha) due to their favourable farm location. There are also few more farmers in the year who obtained still higher income (Table 9). In the subsequent seasons, (Oct 06 – Jan 07 and Oct 07 – Jan 08) more than 55 per cent of the households had a gross income of more than Rs. 25,000/ha. There are also few farmers in these seasons who had a higher income of more than Rs 36,000/ha, indicating that with good management of the land and water it is possible to improve the crop productivity and income. Hence it is important to see the good management practices followed by the farmers in these locations The average gross income per hectare from paddy cultivation was fluctuating over years i.e., Rs.7500 during 2005, Rs 17850 during 2006 and Rs 21900 during 2007.

Given the higher cost of cultivation, the profit level is much less. It is observed that during 2006, the profit is about Rs 3695/ha which has increased to Rs 6405/ha in 2007 indicating the risks in paddy cultivation in the coastal regions.(Table 10). During the same period, the profit level in paddy cultivation in neighbouring district of Tanjore was ranging from Rs 5600 to Rs 8500 /ha (CARDS, 2007).

4.3 Technical Efficiency in Paddy production

The technical efficiency estimates of the stochastic frontier production and the frequency distribution of the technical efficiency among the farmers in different years are given in Tables 11 and 12. It is observed that there is no significant difference in the overall mean technical efficiency of the farmers after tsunami. The technical efficiency level of 80-90% has increased marginally during 2006 and 2007. However, few farmers are still under below average technical efficiency levels of less than 40%. The overall mean technical efficiency is around 83% indicating the scope for increasing the technical efficiency further by 17% through improved crop management practices.

4.4 Effect of Tsunami on Soil and Water

The average soil EC before the tsunami was 1.0 dS m^{-1}, within the range of 0.4 to 4.9 dS m^{-1}. The average soil EC immediately after the tsunami was 5.9 dS m^{-1}, within the range of 0.3 to 23.1 dS m^{-1}. In 2006 and 2007, the average soil ECs were 0.8 dS m^{-1} and 0.6 dS m^{-1}, respectively, within ranges of 0.01 to 11.0 dS m^{-1} and 0.3 to 3.8 dS m^{-1}, respectively.(Figure 5)

Before the tsunami, soil pH ranged from 6.9 to 8.6 with an average of 7.6. Afterwards, it ranged from 6.3 to 9.6 with an average of 8.0, and decreased to 7.8 in 2006. In 2007, average soil pH was 7.9, and ranged from 6.5 to 8.8. (Figure 6).

The average groundwater EC of ten bore hole wells are shown in Figure 7. The groundwater EC ranged from 1.6 to 3.1 dS m^{-1}. Although the increase trend in groundwater EC was observed, we consider that this level should be lower than just after tsunami. Because, immediately after the tsunami the groundwater EC ranged from 3.9 to 46.0 dS m^{-1} (Chaudhary et al. 2006) and it should be more that 20 dS m^{-1} (Chandrasekharan et al. 2008).

The results of the soil and water analysis had shown that the salt deposited by seawater during the tsunami was rapidly leached out by rainfall. From these results, we conclude that the agricultural environment of the district recovered rapidly after the tsunami as shown by Kume et al., 2009.

5. Summary and Conclusions

The results had indicated that about 77 per cent of the households were with farming before tsunami and it has reduced to 25-37 percent after tsunami. In the non-farm sector, 10 per cent of the sample households were involved in non farm activities before tsunami and this has increased to 24 – 38 per cent after tsunami. The percent distribution of labour households is about 50 percent after tsunami compared to only 11 percent before tsunami. The technical efficiency in paddy production was ranging from 80-90% and few farmers are still under below 40 percent technical efficiency. The overall mean technical efficiency is around 83% indicating the scope for increasing the technical efficiency further by 17% through improved crop management practices.

The results of the soil and water analysis had shown that the salt deposited by seawater during the tsunami was rapidly leached out by rainfall, and the vegetation rapidly recovered. From these results, it is concluded that the agricultural environment of the district recovered rapidly after the tsunami.

The profit has marginally increased from Rs 3695/ha in 2006 to Rs 6405/ha in 2007 compared to adjacent non-tsunami regions which was ranging from Rs 5600 to Rs 8500 /ha confirming the coastal risks in paddy production.

5.1 Policy recommendations

Since farmers are incurring crop losses in the region, incorporation of crop insurance programmes in agriculture should be given high priority. Both commercial banks, agricultural extension departments of the Government and NGOs should initiate actions on this.

The technical analysis had indicated that still technically efficiency is as low as 60 percent in few cases. Hence proper exposure to crop management practices should be made. The yield gap among the upper efficiency levels should be bridged.

Flooding is a recurrent phenomenon in the region. Proper land management practices including watershed management in the upstream should be planned as a long-term strategy.

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Table. 1. Effect of Tsunami on Occupation of the Households

Occupation category	Before tsunami		After tsunami					
	2004		2005		2006		2007	
	No	%	No	%	No	%	No	%
Farming	184	76.67	58	24.17	61	25.42	89	37.08
Non farming	23	9.58	57	23.75	90	37.50	48	20.00
Farm labour	26	10.83	117	48.75	80	33.33	96	40.00
Fishing	5	2.08	5	2.08	5	2.08	5	2.08
Unemployed	0	0.00	1	0.42	1	0.42	0	0.00
Temple land	2	0.83	2	0.83	2	0.83	2	0.83
Total	240	100.00	240	100.00	240	100	240	100.00
Degrees freedom			5		5		5	
Calculated chi-square value			105.48		93.9		60.63	
Table chi-square value (5% level)			11.07		11.07		11.07	
Test of significance			Significant		Significant		Significant	

Table. 2. Participation of Family Members in Different Occupation Categories

No. of family members	2004		2005		2006		2007	
	No	%	No	%	No	%	No	%
i) Farming								
1	105	78.36	5	55.56	63	80.77	132	91.03
2	24	17.91	3	33.33	14	17.95	12	8.28
3	4	2.99	1	11.11	1	1.28	1	0.69
4	0	0.00	0	0.00	0	0.00	0	0.00
5	1	0.75	0	0.00	0	0.00	0	0.00
Total	134	100.00	9	100.00	78	100	145	100
ii) Allied activities (livestock, poultry)								
1	5	62.5	5	62.5	4	57.14	5	71.43
2	3	37.5	3	37.5	3	42.86	2	28.57
Total	8	100	8	100	7	100	7	100
iii) Non - farming (shop, etc)								
1	10	76.92	8	72.73	10	76.92	9	75
2	3	23.08	3	27.27	3	23.08	3	25
Total	13	100	11	100	13	100	12	100
iv) Hired work								
1	117	63.93	123	64.06	119	63.30	114	68.67
2	56	30.60	57	29.69	59	31.38	40	24.10
3	10	5.46	11	5.73	10	5.32	12	7.23
v) old age pension scheme	0	0.00	1	0.52	0	0.00	0	0.00
Total	183	100	192	100	188	100	166	100

Table. 3. Seasonwise Rainfall Distribution in Nagapattinam District (mm)

Year	South-west Monsoon	North-east Monsoon	Winter Rainfall	Summer Rainfall	Annual Rainfall
1993-94	349.5	665.6	119.5	41.7	2418.3
1994-95	89.4	700.6	80.1	196.5	2308.6
1995-96	275	556.1	9.7	67.3	2150.1
1996-97	509.7	1070.4	31.8	61	2914.9
1997-98	251.3	1417.2	22.5	122	3055
1998-99	230.9	1036	103.8	99.5	2712.2
1999-2000	113.2	897.3	394	26.5	2673
2000-01	200.7	742.9	6	133.6	2325.2
2001-02	257.9	818.1	338.7	32.2	2688.9
2002-03	147.3	777.7	9.5	63.5	998
2003-04	257.5	786.6	14.2	347.7	1406
2004-05	347	1085.3	2.8	226.3	1661.4
2005-06	291.1	1165.9	36.7	128.6	1622.3

Normal rainfall: South-west Monsoon: 274.1 mm; North-east Monsoon : 886.4 mm; Winter Rainfall: 81.5 mm; Summer Rainfall: 99.7 mm. Annual rainfall: 1341.7 mm

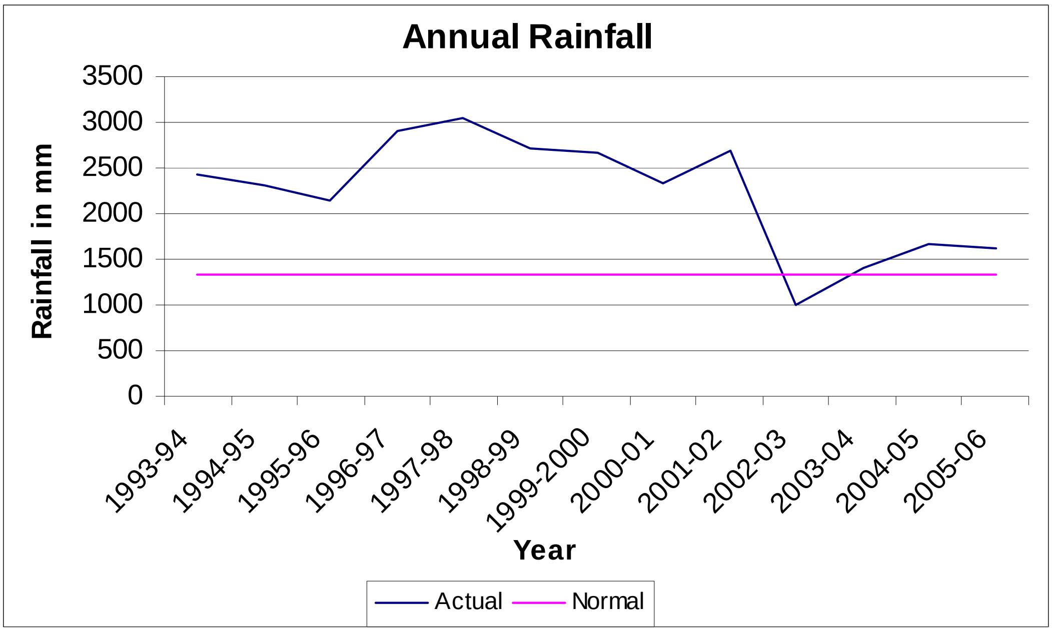


Fig.2. Total Annual Rainfall of Nagapattinam District

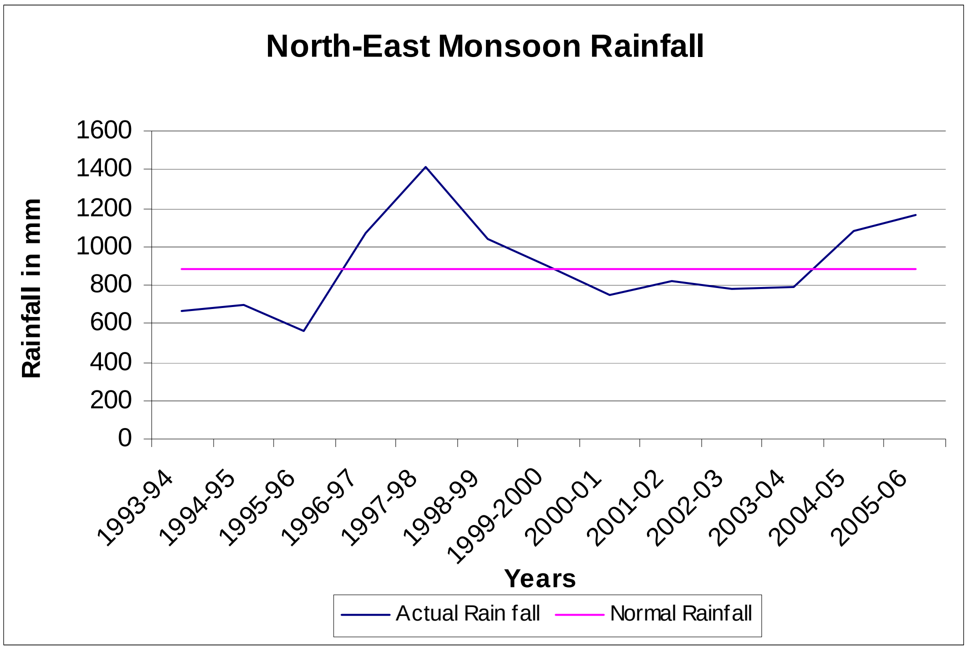


Fig.3. North-East Monsoon Rainfall of Nagapattinam District

Table. 4. Crop Production in summer season (Jan-May).

Category	2004		2005		2006		2007	
	No.	%	No.	%	No.	%	No.	%
Temple land	2	0.83	2	0.83	2	0.83	2	0.83
Not cultivating	229	95.42	229	95.42	236	98.33	235	97.92
Cultivating Cashew (*Anacardiumoccidentale)*	1	0.42	1	0.42	0	0.00	1	0.42
Cultivating Coconut (*Cocos nusifera)*	3	1.25	3	1.25	1	0.42	2	0.83
Cultivating Mango (*Mangifera indica)*	2	0.83	2	0.83	0	0.00	0	0.00
Cultivating Blackgram (*Vigna mungo)*	0	0.00	2	0.83	0	0.00	0	0.00
Current Fallow	1	0.42	0	0.00	0	0.00	0	0.00
Leased out	2	0.83	1	0.42	1	0.42	0	0.00
Total	240	100.00	240	100.00	240	100.00	240	100.00

Table. 5. Crop Production in Season I (June- September)

Category	2004		2005		2006		2007	
	No.	%	No.	%	No.	%	No.	%
Temple land	2	0.83	2	0.83	2	0.83	2	0.83
Not cultivating	231	96.25	231	96.25	236	98.33	237	98.75
Cultivating Paddy (*Oryza sativa*)	5	2.08	5	2.08	1	0.42	0	0.00
Cultivating Ragi (*Eleusine coracane)*	2	0.83	2	0.83	1	0.42	1	0.42
Total	240	100.00	240	100.00	240	100.00	240	100.00

Table. 6. Crop Production in Season II (October – January)

Category	2004 (Oct 04– Jan 05)		2005 (Oct 05– Jan 06)		2006 (Oct 06 – Jan 07)		2007 (Oct 07- Jan 08)	
	No.	%	No.	%	No.	%	No.	%
Temple land	2	0.83	2	0.83	2	0.83	2	0.83
Not cultivating	80	33.33	128	53.33	176	72.92	94	39.17
Cultivating Paddy(*Oryza sativa*)	155	64.58	105	43.75	61	25.83	144	60
Cultivating Black gram (*Vigna mungo)*	1	0.42	0	0	0	0	0	0
Cultivating Fodder Sorghum (*Sorghum vulgare)*	1	0.42	1	0.42	0	0	0	0
Cultivating Cassuarina (*Caurina eqisetifolia)*	0	0.00	1	0.42	0	0	0	0
Leased out	1	0.42	3	1.25	1	0.42	0	0
Total	240	100	240	100	240	100	240	100

Table 7. Cost of Cultivation of Paddy in Season II (Rs/ha)

Cost category (Rs/ha)	2004 (Oct 04 – Jan 05		2005 (Oct 05 – Jan 06)		2006 (Oct 06 – Jan 07		2007 (Oct 07 – Jan 08)	
	No	%	No	%	No	%	No	%
Upto 5000	42	27.10	10	9.52	0	0.00	17	11.81
5000-7500	27	17.42	27	25.71	5	8.20	24	16.67
7500-10000	25	16.13	23	21.90	18	29.51	22	15.28
10000-12500	18	11.61	13	12.38	7	11.48	18	12.50
>12500	43	27.74	32	30.48	31	50.82	63	43.75
Total	155	100.00	105	100.00	61	100.00	144	100.00

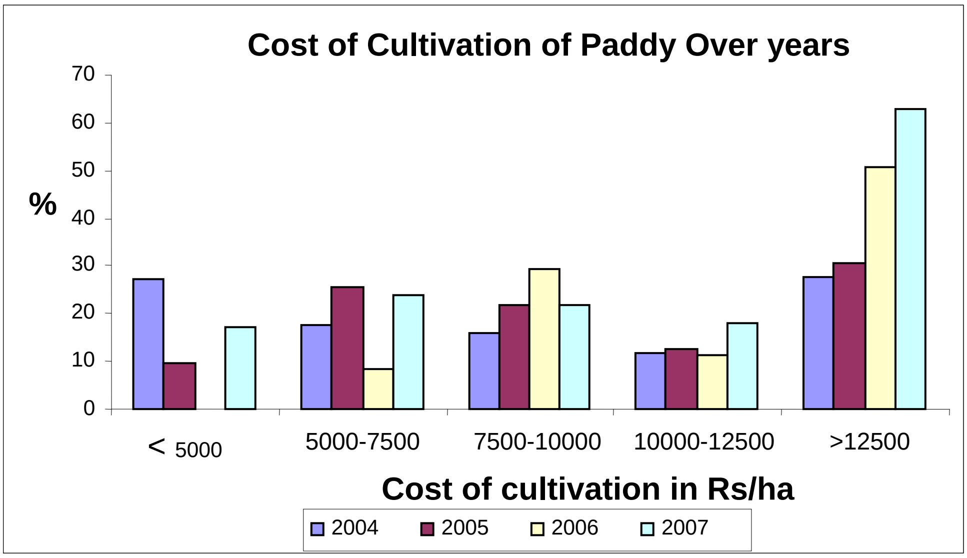


Fig.4. Cost of cultivation of Paddy for consecutive four years

Table 8 .Detailed Cost of Cultivation of Paddy (Rs/ha)

Items	2004		2005		2006		2007	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1.Seedrate (kg)	95	540	100	500	140	1077	148	1284
2.Fertilizers (kg)	460	2550	508	2633	360	2270	300	2066
3. No of chemical Spraying	2	502	2.67	566	2	290	2	283
4.Green manure (t)	0	0	0	0	0	0	2	500
5. FYM (t)	2.25	1565	2.23	1816	2.3	1150	2	1006
6.Machine power for land preparation (hrs)	5.5	1475	6.33	1792	1.8	810	30	3037
7.Machine power for harvesting/ threshing (hrs)	0.91	135	0	0	2	500	0	0
8. Labour (days) for:								
Land preparation	0	0	4.33	93.33	24.4	2120	2	911
Sowing/planting	6.65	580	6.67	558.33	26.8	1608	26	1507
Chemical spraying	1.82	164	2.17	208.33	1.8	255	2	272
Fertilizer Application	2.25	205	1.83	183.33	1.8	255	2	278
Weeding	15.25	655	9.83	458.33	22	1320	18	1087
Harvesting/ Threshing	0	0	4.33	260.00	30.6	2500	39	3272
Cost of cultivation		**8371**		**9068.66**		**14155**		**15502**
Yield :								
1. Main product (kgs)	Crop failed		Crop failed		2600	16900	2760	20923
2. By product (kgs)					1100	950	1222	983
Gross income						**17850**		**21907**

Table. 9. Distribution of Gross Income Among Farmers (Rs/ ha)

Income Category (Rs/ha)	2004		2005		2006		2007	
	(Oct 04 – Jan 05)*		(Oct 05 –Jan 06)		(Oct 06 – Jan 07)		(Oct 07– Jan 08)	
	No	%	No	%	No	%	No	%
Crop failure	240	100	74	70.48	1	1.64	0	0
upto 8750	0	0	0	0	0	0	0	0
8750-11250	0	0	0	0	0	0	2	1.39
11250-13750	0	0	0	0	2	3.28	11	7.64
13750-16250	0	0	0	0	2	3.28	10	6.94
16250-18750	0	0	0	0	3	4.92	10	6.94
18750-21250	0	0	0	0	11	18.03	20	13.89
21250-23750	0	0	12	11.43	5	8.2	24	16.67
23750-26250	0	0	6	5.71	10	16.39	21	14.58
26250-28750	0	0	9	8.57	15	24.59	12	8.33
28750-31250	0	0	4	3.81	8	13.11	17	11.81
31250-33750	0	0	0	0	2	3.28	11	7.64
33750-36250	0	0	0	0	0	0	3	2.08
>36250	0	0	0	0	2	3.28	3	2.08
Total	240	100	105	100	61	100	144	100

Table 10. Gross and Net Income of the Paddy Farmers in the Coastal Area (Rs/ha)

	2004	2005	2006	2007
Gross Income	0*	7500	17850	21907
Cost of cultivation	8837	9068.66**	14155	15502
Net income	-8837	-1568.66	3695	6405

*crop failure due to tsunami

** Poor yield and income due to flooding and poor soil quality

Table 11. Maximum Likelihood Estimates (MLE) of the Stochastic Frontier Production Function (after Tsunami)

Variables	2005		2006		2007		Pooled	
	Coefficient	**t-ratio**	**Coefficient**	**t-ratio**	**Coefficient**	**t-ratio**	**Coefficient**	**t-ratio**
Intercept	5.6063	70.2372	5.2579	6.3806	6.0309	5.6221	5.3173	8.6641
Area (ha)	0.8436	5.2584	0.1279	0.6141	0.2826	1.3304	0.4729	3.4742
Seed rate (kg)	0.3710	4.7254	0.2083	1.1001	0.4013	2.3221	-0.0441	-0.3432
Fertilizer (kg)	0.1010	2.7692	0.1870	1.5590	-0.2679	-2.1813	0.3145	3.9251
FYM (tons)	0.1356	1.4969	0.1682	1.3432	-0.0143	-0.2004	0.0743	1.2879
Labour (man days)	-0.0830	-0.9587	0.1575	0.8374	0.3206	4.0400	0.2223	2.7847
sigma-squared	0.0603	5.5234	0.0693	1.9892	0.0684	3.5095	0.1391	4.5919
Gamma	1.0000	420.8932	0.9034	4.5254	0.8859	10.3915	0.8806	10.4901
Log likelihood value	21.36		21.26		17.53		1.5302	

Table 12. Frequency Distribution of Technical Efficiency of the Farms (After Tsunami)

Technical Efficiency	Frequency Distribution			
	2005	**2006**	**2007**	**Pooled**
30-40	0 (0.00)	0 (0.00)	1 (2.17)	1 (0.75)
40-50	0 (0.00)	0 (0.00)	0 (0.00)	3 (2.26)
50-60	2 (6.25)	2 (3.64)	0 (0.00)	9 (6.77)
60-70	2 (6.25)	6 (10.91)	2 (4.35)	30 (22.56)
70-80	7 (21.88)	9 (16.36)	9 (19.57)	20 (15.04)
80-90	11 (34.38)	21 (38.18)	20 (43.48)	50 (37.59)
90-100	10 (31.25)	17 (30.91)	14 (30.43)	20 (15.04)
Total	32 (100.00)	55 (100.00)	46 (100.00)	133 (100.00)
Mean	82.97	82.91	83.88	77.21
Maximum	99.93	96.34	96.64	96.07
Minimum	55.29	52.52	39.03	38.53

Figures in brackets are percent to total.

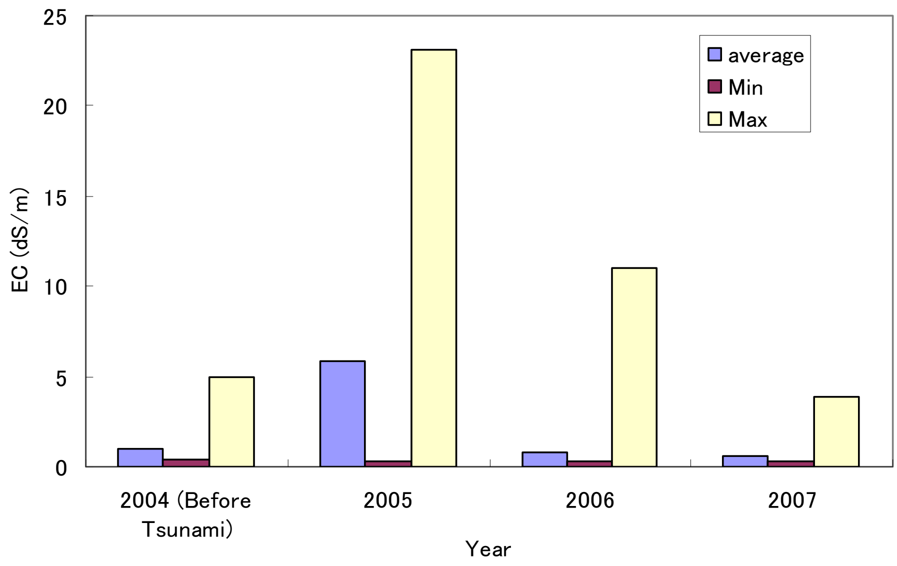


Fig 5. Changes in soil EC pre (2004) and post the tsunami (2005-2007)

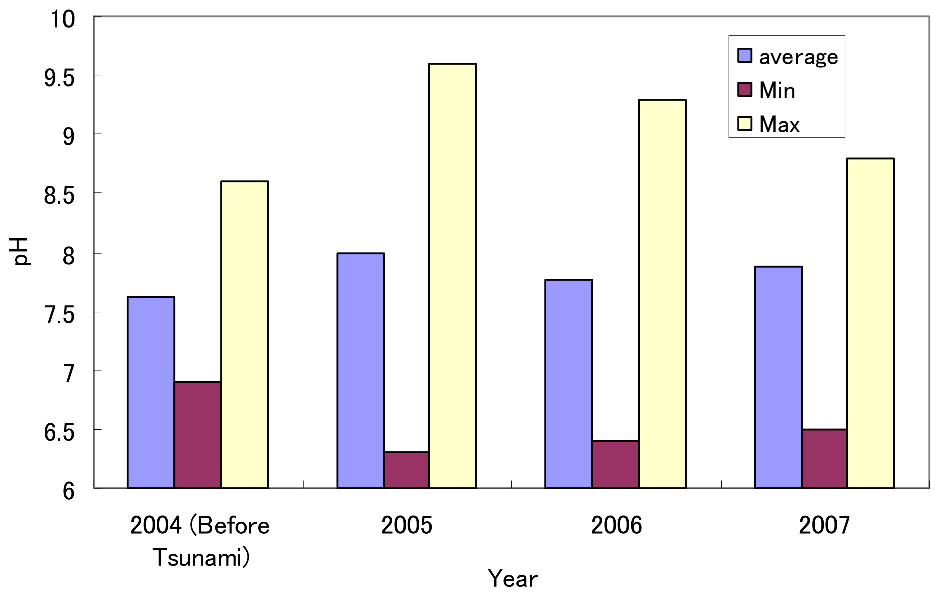


Fig 6. Changes in soil pH pre (2004) and post the tsunami (2005-2007)

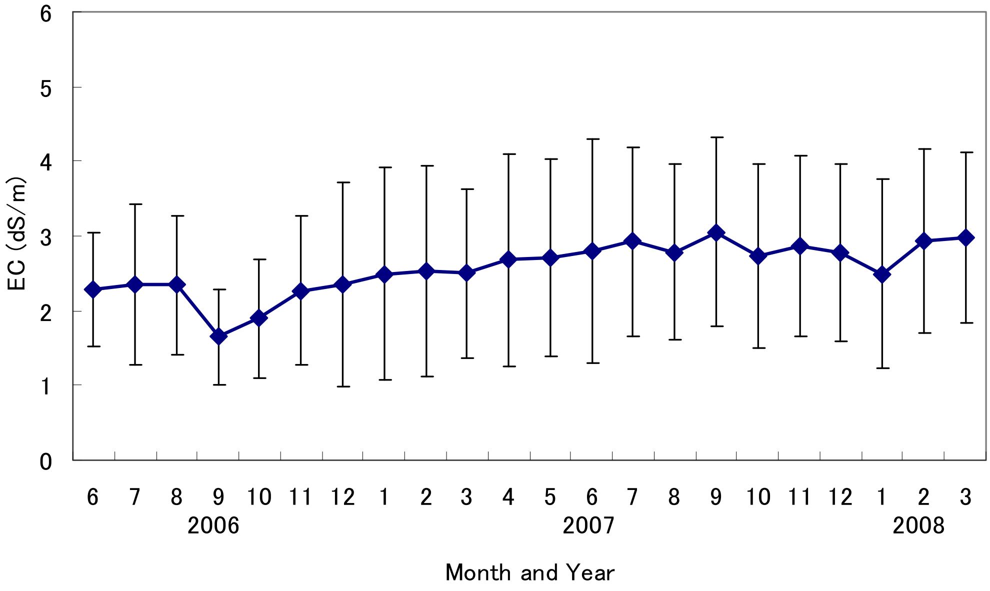


Fig 7. Monthly changes in average value groundwater EC between June 2006 and March 2008

The 2nd Lusaka Workshop on Vulnerability and Resilience of Social-Ecological Systems

"Towards Resilience of Rural Households in Drought-Prone Areas"

Date and Time: 28 August 2009, 8:30-17:30

Venue: Mika Lodge, plot # 106, Corner 1st street & Central Street, Jesmodine, Lusaka

Organized by: Resilience Project, Research Institute for Humanity and Nature, Japan; and Zambia Agricultural Research Institute (ZARI)

Purpose of the Workshop

In the Semi-Arid Tropics (SAT) where people largely depend on vulnerable rainfed agricultural production systems, protecting human security of the people in the region is an acute issue. To enhance the human security of the region, it is essential to consider how to enhance the resilience and reduce vulnerability of the livelihoods. In order to examine the resilience of SAT, it is vitally important to consider resilience of social-ecological system as an integrated system. In the workshop, we consider resilience to environmental variability, such as drought and flood, and social changes. Secondly we consider resilience for protecting human security, i.e. survival, livelihoods and dignity. Finally we consider resilience of food supply and consumption, health status, agricultural production and livelihoods. The workshop aims at identifying the factors affecting resilience and the ways to enhance the resilience to environmental variability of rural people in drought-prone areas.

Workshop Program

Time	Program
8:30-9:00	**Registration**
9:00-9:30	**Opening speech:** by Yukihiko Nakamura, Embassy of Japan in Zambia **Welcome speech:** by Watson Mwale, Director of ZARI **Overview of the Resilience Project:** by Chieko Umetsu, project leader "Resilience of rural households: The way forward for rural development"
9:30-10:50	**Session I: Climatic variation and ecological resilience** **Session chair: Moses Mwale, ZARI** 1. S. Sokotela et al. *ZARI*,"Demonstration and evaluation of agro-forestry plants in soil fertility restoration for sustainable agriculture at Mwelwa village in chief Sandwe's area of Eastern Zambia" 2. A. Yatagai, *RIHN*, "Precipitation analysis based on satellites and rain-gauge over Zambia" 3. M. Ndebele-Murisa, *Univ., of Zimbabwe*, "The fate of phytoplankton in a changing world and the link to fisheries livelihood" 4. H. Shinjo et al. *Kyoto Univ.*, "Land clearing impact on crop productivity and soil conditions in a Miombo woodland in Eastern Province, Zambia"
15-Minute Tea Break	
11:05 -12:25	**Session II: Food production, livelihood system and household resilience** **Session chair: Kazuo Hanzawa, Nihon University** 1. C.Chabatama, *Univ., of Zambia*,TBA 2. C. Ito, *Kyoto Univ.*, "Qualitative analysis of livelihood diversity in rural Zambia: Focusing on process and access" 3. T. Sakurai, *Hitotsubashi Univ.*, "What is resilience in the face of variable rainfall in rural Zambia?" 4. G. Kajoba, *Univ.,of Zambia*, "The impact of droughts and floods and vulnerability of the food system in Zambia"
75-Minute Lunch Break	
13:40-15:20	**Session III: Poverty, nutrition and health situation** **Session chair: Gear Kajoba, UNZA** 1. M. Mate, *Met Dept., Livingston*, "Promotion of climate information for effective agriculture planning in drought prone districts of Kalomo and Kazungula in Southern Province of Zambia" 2. B. Siamwiza, *Univ., of Zambia*, "Surviving impact of drought in a semi-arid region: The case of the Gwembe valley" 3. T. Yamauchi, *Hokkaido Univ.*, "Growth and nutritional status of children and adults living in contrasting ecological zones in the Southern Province of Zambia" 4. T. Lekprichakul , *RIHN*, "Is child obesity a new face of under-nutrition in Zambia?" 5. C. Mulenga, *Univ., of Zambia*, "Food security in the context of climate change and variability"
15-Minute Tea Break	
15:35-17:15	**Session IV: Adaptation, vulnerability and resources** **Session chair: Shiro Kodamaya, Hitotsubashi University** 1. M. Yoshimura, *RESTEC*, "Concept of multi-dimensional data integration in Southern Province" 2. M. Yamashita & H. Miyazaki, *Survey College of Kinki*, "Land use/cover mapping for understanding the livelihoods at village level using multi-spatial and temporal data" 3. Y. Ishimoto, *RIHN*, "Social Network as Insurance in Tonga Community: a preliminary report" 4. M. Okamoto, *RIHN*, "Some problems of cattle grazing among the Gwembe Tonga along the Lake Kariba" 5. K. Matsumura, *Kyoto Univ.*, "Food security institution in Zambia: A case study of food aid in Sinazongwe District, 2005-2008"
15-Minute Break	
17:20-18:00	**Discussion and conclusion**

The Indian Ocean Tsunami: 5 Years Later

Assessing the Vulnerability and Resilience of Tsunami Affected Coastal Regions

Date: 1-3, March, 2010

Venue: Victoria room, Hotel Grand Pacific, Singapore

Address: 101 Victoria Street, Singapore 188018

Tel: +65 6336 0811 Fax: +65 6339 7019

Pre-workshop, 28 Feb. (Sun)

17:00 Registration (Sophia room, Level 2 of Hotel Grand Pacific)

18:30 Reception (Sun's Café, Level 1 of Hotel Grand Pacific)

1st day, 1 Mar (Mon)

9:45 Registration

Opening

10:00 Greeting and welcome address

(Dr. Umetsu, RIHN)

SESSION 1 Tsunami affected agriculture and hydrological process in coastal area

(Chair: Mr. Miyazaki)

10:15 Recovery of Agricultural Field from the 2004 Tsunami in Coastal Area of Tamilnadu, India

(Dr. Kume, RIHN)

10:45 Impact of the 26-12-04 Tsunami on the Indian Coastal Groudwater: Did we learn from the Disaster?

(Dr. Neupane, UNESCO)

11:15 Development of a Tsunami Warning System for Thailand

(Dr. Muangsin, Chulalongkorn Univ.)

11:45 Short Discussion and Summary (15 min)

12:00– 13:30 Lunch (Sun's Café)

SESSION 2 Building socio-ecological systems after tsunami

(Chair: Dr. Palanisami)

13:30 Social and ecological consequences of intensive efforts in rebuilding coastal fishery-related livelihoods in Sri Lanka after the 2004 Asian Tsunami

(Dr. Manatunge, Moratuwa Univ.)

14:00 Resilience of tourist coasts to the 2004 Indian Ocean tsunami

(Dr. Wong, Univ. of Singapore)

14:30 Short Discussion and Summary (15 min)

14:45 – 15:15 Tea Break

SESSION 3 Post tsunami study in Ache, Indonesia

(Chair: Dr. Manatunge)

15:15 The Role of Houses in the Post-Tsunami Reconstruction in Aceh, Indonesia

(Dr. Yamamoto, Kyoto Univ.)

15:45 Current Status of Aceh Tsunami Digital Repository

(Dr. Dirhamsyah, Syiah Kuala Univ.)

16:15 Short discussion and summary (15 min)

16:30 Closing

2nd day, 2 Mar (Tue)

SESSION 4 Study on social and people's recovery from tsunami in India

(Chair: Dr. Wong)

10:15 Strategies for Technological empowerment of Tsunami affected Rice farmers

(Dr. Sundaram, Kerala Agri. Univ.)

10:45 Rehabilitation of Tsunami Affected Farmers through Integrated Agricultural Technological Interventions in Andaman Islands

(Dr. Srivastava, CARI)

11:15 PTSD symptoms and recovery among different sectors of the people exposed to 2004 Tsunami in Tamil Nadu, India

(Dr. Shanthasheela, TNAU)

11:45 Short Discussion and Summary (15 min)

12:00 – 13:30 Lunch (Sun's Café)

SESSION 5 Agriculture and household recovery from tsunami in Tamilnadu, India

(Chair: Dr. Kume)

13:30 Impact of and Recovery from Tsunami 2004- focus on rural households, Tamilnadu, India

(Dr. Jegadeesan, TNAU)

14:00 Impact of and Recovery from Tsunami 2004 - focus on agricultural productivity and income, Tamilnadu, India

(Dr. Palanisami, IWMI-TATA)

14:30 Resilience of Tsunami Affected Households in Coastal Region of Tamil Nadu, India

(Dr. Umetsu and Dr. Lekprichakul, RIHN)

15:00 Short Discussion and Summary

15:15 – 15:45 Tea Break

SESSION 6 Discussion on vulnerability and resilience of tsunami affected areas

15:45 Discussion

(Chair: Dr. Umetsu and Dr. Kume, RIHN)

17:15 Closing Remark

(Dr. Palanisami, IWMI-TATA)

3rd day, 3 Mar (Wed)

9:00 Business Meeting for Publication of Tsunami Book

(Tea Break 10:30-10:45)

12:00 Finish

12:00 – 13:30 Lunch (Sun's Café)

Abstract of Resilience Seminar in FY2009

The 27th Resilience Seminar

Date & time: July 8th 2009, 15:00-16:00

Place: RIHN Seminar Room 3, 4

Title: Quantifying the impact of climatic change on yields and yield variability of major crops and optimal land allocation for maximizing food production in different agro-climatic zones of Tamil Nadu, India: An Econometric Approach

Speaker: C.R. Ranganathan (Affiliation: Professor, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India)

Language: English

[Abstract]

This paper provides a framework for optimal land use planning in the context of climate change. All agricultural activities are very sensitive to climate change resulting in variability in crop yields. Hence it becomes necessary to study the effect of climate change not only on mean yield but also on variability in yield. The quantitative information so obtained should be used for optimal land allocation in order to utilize natural resources in a judicious way.

Previous studies using regression techniques concentrated on the estimation of average productivity only but little attention was given for optimal land allocation to competing crops with climate change induced productivities. The problem becomes more important in the context of gradual decline in available land area for agriculture due to urbanization.

The present study focuses on these issues for major crops grown in Tamil Nadu State. It employs econometric modelling for estimating the mean yield and yield variability and also covariance between yields of different crops. The mean yields so obtained which reflect the impact of climate change are then used in multi-objective linear programming models for meeting objectives like maximum food grain production, maximum paddy production and minimization of agricultural land area for maintaining at least the current level of production of crops etc. Finally the study attempts to link the optimal food grain production with the projected population of Tamil Nadu for 2020 to determine the quantum of food grain availability per individual.

The study shows that precipitation and temperature have varying effect on productivity and variability of crops. Trend has positive impact on most of the crops. Also, climate change, as dictated by HADCM3A2a scenario, will have modest impact on crop productivities across the five zones of Tamil Nadu. Zones where paddy is grown traditionally may witness modest increase in productivity followed by increase in variability while many other crops may have decrease in productivity and there is no uniformity in changes in their variability. The study indicates that when land is the only constraint, with climate change induced productivities, optimal allocation of crop area will result in increased production of food grain. These results will be useful for policy makers in finding the gap between supply and demand of food grain for projected population.

The 28th Resilience Seminar

Date & time: August 3rd 2009, 15:00-16:00

Place: RIHN Seminar Room 3, 4

Title: A Spatial Structure for the Institutional Analysis of Common Pool Resource Systems

Speaker: Tom Evans (Associate Professor, Department of Geography, Indiana University, Indiana, USA)

Language: English

[Abstract]

Dynamics within common pool resource (CPR) systems are the product of a diverse array of socio-economic and biophysical processes. The spatial structure of these systems often influences the management of resources (e.g. forests, water, fish) including the institutional rules that are developed governing how these systems can be used. Prior work has developed frameworks to describe social-ecological systems (SES) to investigate the institutional contexts that make SESs resilient or sustainable, but without articulating the spatial relationships inherent in these systems. The objective of this paper is to develop an ontology designed to describe the actors, resources and relationships within an SES, with an emphasis on the spatial relationships inherent in human-environment interactions. The field of computer science uses the term "ontology" to refer to an implementation of a conceptual framework. From an analytical perspective, ontologies can be used to translate data compiled for case studies into a formal database that enables cross-site analysis. Many elements of SESs have explicitly spatial characteristics that in part affect the dynamics within those systems such as the proximity of actors to a resource, or the size of land holdings. The ontology presented here emphasizes the actors and resources in a system as well as the spatial characteristics and relationships that relate to the institutional factors affecting system dynamics. A series of three distinct case studies (a community forest in Midwest United States, an irrigation network in southwest United States and a fishery system in Mexico) are used to demonstrate how this ontological framework can be applied to specific CPRs and social-ecological systems more generally.

The 29th Resilience Seminar

Date & time: October 30th 2009, 17:00-18:00

Place: RIHN Lecture Hall

Title: Agriculture and Rural Community of Africa as Object of Technical Cooperation

Speaker: Yoshitake Shinbo (Managing Director, Technical Support Office for Rural Development in Kinki District, Ministry of Agriculture, Forestry and Fisheries, Japan)

Language: Japanese

[Abstract]

In sub-Saharan Africa, farming system is largely a small-scale rain-fed agriculture. This is in sharp contrast to the well irrigated systems in which large-scale commercial plantations, especially

those in southern Africa, are using. The productions of subsistence crops of small scale farmers are diverse. Maize, wheat, millet, sorghum and other grains are main staple food in the sub-Saharan. In Uganda and the surrounding countries, non-sweet banana is their staple food. Rice including the upland rice is increasing in its importance in many African countries.

It is argued that a well managed irrigation system is a key to improve livelihood and food security of the small scale farmers. Existing community irrigation systems such as well and pond in many African countries tend to be small in capacity and not as efficiently managed as of those water users' associations in the monsoon Asia. The Japanese technical cooperation has targeted irrigation system that will allow the farmers to cultivate horticulture in the dry season to supply to the market for additional income. Although it is important to have stable yield of cereal and staple crops, their prices under government-operated market are generally too low to be profitable to increase production of cereal crops. In order for technical assistance to be effective, it is important to consider technology, tools or means that are appropriate within the context of ecological and market environment semi-arid of sub-Saharan Africa, which may probably be different from successful technical development experiences of monsoon Asia.

List of Working Paper on Social-Ecological Resilience Series

No. 2008-001 Moses Mwale, *Synthesis of Soil Management Options for Better Targeting of Technologies and Ecological Resilience under Variable Environmental Conditions*

No. 2008-002 Thamana Lekprichakul, *Impact of 2004/2005 Drought on Zambia's Agricultural Production and Economy: Preliminary Results*

No. 2008-003 Gear M. Kajoba, *Vulnerability and Resilience of Rural Society in Zambia: From the View Point of Land Tenure and Food Security*

No. 2008-004 Lawrence S Flint, *Socio-Ecological Vulnerability and Resilience in an Arena of Rapid Environmental Change: Community Adaptation to Climate Variability in the Upper Zambezi Floodplain*

No. 2008-005 Tetsuya Nakamura, *The Livelihood of 'Escarpment Tonga': A Case Study of One Village, Southern Zambia*

No. 2008-006 Chihiro Ito, *Re-thinking Labour Migration in Relation to Livelihood Diversity in African Rural Area: A Case Study in Southern Province, Zambia*

No. 2009-007 Matheaus Kioko Kauti, *Rural Livelihood Security Assessment for Smallholders Undergoing Economic Changes and Agro-ClimaticEvents in Central Kenya*

No. 2009-009 Gear M.Kajoba, *Vulnerability of Food Production Systems of Small-Scale Farmers to Climate Change in Southern Zambia: A Search for Adaptive Strategies*

No. 2009-010 Chileshe L. Mulenga, *Resilience of Rural Households and Communities to Economic Shocks, HIV/AIDS and Recurrent Droughts: The Case of Households and Communities in the Mwami Area, Chipata, Zambia*

FY2009 E-04 (FR3) Project Research Activity Overview												2010.2.12
2009	4	5	6	7	8	9	10	11	12	1	2	3
Resilience Seminar				15:00–16:00	15:00–16:15		16:00–17:00					
				July 8th	August 3rd		October 30th					
				(27th)	(28th)		(29th)					
Core-mamber Meeting	＊4/11		＊6/6		＊8/7		＊10/30		＊12/4		＊2/26	
Workshop			Planning WS 6/6		2nd Lusaka WS		Project WS 10/30–31					Tsunami WS
			10:00–17:00		28-Aug		RIHN				16:00–17:30	3/1–3 Singapore
Study Meeting			The 8th WS		(The 9th WS)		The 10th WS				＊2/26	(The 11th WS)
FR2 Project Report									FR2 Project Report due		Printing	HP upload
	NIHU				(Special budget	(Special budget			(FR3 budget	H22 budget	H22 budget	H23 budget
	Grant application				application 8/24	hearing 9/18)			report 12/17)	8-Jan	hearing	plan
FR Related Meetings	4/26–30										12-Feb	
	IHDP Bonn								12/2–12/4			(FS Hearing)
	(IS application 4/7)					(IS hearing)			IHDP/ESG			5-Mar
	IS hearing 4/16					4-Sep						
RIHN Events				RIHN Forum			RIHN Int'l Symposium		RIHN Project		PEC	
				5-Jul			20–22 October		Meeting		2/17–18	
				KICC			RIHN		9–11 December		RIHN	
Field Trip Schedule									Coop In Kyoto			
Shinjo	4/14–5/9				8/25 – 9/4			11/(19) 28–12/24			2/11 – 2/25	
Tanaka						9/17–10/2						
Miyazaki	3/16 – 4/27					9/7–10/2					2/1 – 2/15	2/27–3/4 WS
Miura	4/14–5/9											
Shibata												
Takenaka (M2)	4/14–5/9											
Ando (M2)	4/14–5/9						9/30 – 10/22				2/11 – 2/25	
Miyashita (M2)						8/4 – 10/2	2 months					
Sakurai	4/25–5/1 IHDP				8/25 – 8/30		10/4–10/14(28					
Kanno							10/4–10/15					
Shimono	4/1 – 4/11											
Yamauchi					8/20 – 8/30							
Shimada					8/20 – 9/7							
Hanzawa												
Kodamaya					8/18 – 9/3							
Araki					(8/18 – 9/3)							
Okamoto												
Ishimoto	3/5 – 4/5				8/1 – 9/2							
Narisawa (D2)	4/25–5/1 IHDP		4/7 – 9/1			5 months			11/15 – 2/15		3 months	2/27–3/4 WS
Itoh (D1)	(JSPS)											
Nakamura (D1)					8/21 – 9/21							
Kyo (M2)												
Yoshimura					8/24 – 9/5		10/17–10/24					
Saeki												
Yamashita					8/24 – 9/5		10/17–10/21					
Matsumura					8/25 – 9/15							
Umestu	4/25–5/1 IHDP(JSPS)		6/11–6/22		8/20 – 9/24				12/13–21	(India)		2/27–3/4 WS
Lekprichakul	4/25–5/1 IHDP		6/28–7/5	(Vancouver)	8/12 – 9/12	(Zambia, UK)					2/5 – 3/4	(2/28–3/4 WS)
Kume					8/25 – 9/2				(India)	1/17–29	2/27–3/4WS; 3/8–19Sri Lanka	
Yatagai					8/26 – 9/2							
Palanisami	4/24–5/4 IHDP											2/27–3/4 WS
Kajoba	4/25–5/2 IHDP											
Mulenga	4/25–5/2 IHDP											
Ranganathan	4/20 – 7/19	RIHN										
Evans (Visiting Fellow				7/12–8/5 RIHN							1/18 – 6/30	RIHN

はじめに

地球研平成 21 年度フルリサーチ (FR) 研究「社会・生態システムの脆弱性とレジリアンス」は本プロジェクトとしての 3 年目を無事終了した。本プロジェクトは地球研の 5 つの領域プログラムの中で唯一「地球地域学プログラム」に所属している。

平成 21 年度は若手の研究員が長期にザンビア南部州に滞在し、精力的にデータを収集した。今年度は調査をスタートしてから 2 年目の雨季を終え、3 年目の雨季の収穫期に入るところである。東部州ペタウケ郡での、異なる休閑システムが作物収量と土壌に与える影響を調べる実験は継続中である。南部州シナゾングェ郡では、2007/2008 年の農作期に平年の 2 倍を超える 1600 mm の雨量を記録したが、大雨を受けた家計において食料消費が減少していることを明らかにした。農民達は、サツマイモやマメなどへの作付けの転換や、さまざまな現金獲得手段によって、この状況を克服していることが明らかになった。政府系の食糧援助の配布世帯の決定プロセスに関するローカルレベルの分析も進んでいる。衛星データや航空写真を使った土地利用と植生被覆の歴史的変遷の状況把握と広域世帯調査のデータ分析も進行中である。

平成 21 年 4 月にはボンで開催された IHDP2009 オープンミーティングに 8 名のプロジェクトメンバーが参加し、2 つの企画セッションとポスターセッションで発表を行った。8 月にはトンガ研究の第一人者であるカリフォルニア大学バークレー校のエリザベス・コールソン名誉教授をお招きして、ルサカで大学研究者、政府関係者、NGO スタッフ、国際援助機関のスタッフを交えてルサカで第 2 回ワークショップを開催した。「レジリアンス」という視点はとても新鮮に受け入れられ活発な議論が行われた。10 月には、3 年前に地球研が上賀茂の新施設に移動した年に第 12 回レジリアンス研究会の講師をしていただいたインディアナ大学のエリノア・オストロム教授がノーベル経済学賞を受賞するといううれしいニュースもあった。

プロジェクトメンバーの方々にはプロジェクトの順調な発展のためにご尽力をいただき感謝したい。また地球研のプロジェクト評価委員会 (PEC)、所長、プログラム主幹、管理部および研究部スタッフの方々にこの様な統合プロジェクトを実施するためにご支援いただいたことに感謝申しあげる。プロジェクト終了までの間にレジリアンス研究をさらに発展させる基盤をつくるように尽力したいと考える。

平成 22 年 3 月

総合地球環境学研究所
E-04(FR3) プロジェクト・リーダー
梅津　千恵子

プロジェクトタイトル	社会・生態システムの脆弱性とレジリアンス
領域プログラム	「地球地域学」プログラム
プロジェクトリーダー	梅津　千恵子

ホームページ： http://www.chikyu.ac.jp/resilience/

キーワード：レジリアンス，貧困，　社会・生態システム，資源管理，環境変動，脆弱性，人間の安全保障，半乾燥熱帯，適応力

1. 研究プロジェクトの全体像

1）目的と背景

背景：貧困と環境破壊は密接に関係しており，貧困が環境破壊を生み，環境破壊が貧困を生むという悪循環を生み出している。この悪循環は森林破壊や砂漠化などの「地球環境問題」の主原因の一つであると考えられている。世界の貧困人口の大部分は集中するサブサハラ・アフリカや南アジアの半乾燥熱帯に集中し、伝統的なコミュニティ（社会）や環境資源（生態）に強く依存して生業を営んでいる。これらの地域では、天水農業に依存する人々の生活は環境変動に対して脆弱であり、植生や土壌などの環境資源は人間活動に対して脆弱である。ゆえに，さまざまな環境変動に対する社会・生態システムのレジリアンスの低下は深刻な問題となり、システムの保全と強化は重要な課題となっている。よって，この「地球環境問題」の解決のためには，人間社会および生態系が環境変動の影響（ショック）から速やかに回復すること（レジリアンス）が鍵となる。近年の国際的な持続可能性や国際開発の議論の中でもレジリアンスは重要な要素として位置づけられている。

目的：本プロジェクトでは，途上国地域の農村において，旱ばつや洪水などの環境変動に対する社会・生態システム、特に世帯の食料生産と消費システムのレジリアンスを高める方策を考えることを主目的とする。そのため，まず，環境変動に対する人間活動を社会・生態システムの脆弱性とレジリアンスという観点からとらえ，環境変動が社会・生態システムに及ぼす影響とそのショックから回復するメカニズムと対処戦略を明らかにする。また、具体的な事例から社会・生態レジリアンスの要因を特定するために，家計やコミュニティ，そして社会制度が果たしている役割を分析する。これらレジリアンスの要因の特定とショックからの回復メカニズムの解明を通じて，社会・生態レジリアンスの本質を明らかにする。そして，レジリアンスを高めるための方策を議論し，途上国地域において人間の安全保障を醸成するための示唆を与える。調査対象地域は、ザンビア（南部州、東部州）を中心とした半乾燥熱帯の旱ばつ常襲地帯である（図１）。

2）地球環境問題の解決にどう資する研究なのか？

環境変動の被害は社会経済的に脆弱なグループがまず被害を受ける。本プロジェクトでは，社会・経済システムの脆弱性を「地球環境問題」として捉え，脆弱性を規定する要因を解明し，途上国農村で地域社会のレジリアンスを高める方策を提案することが「地球環境問題」の解決につながると考える。現地での実験、測定，インタビュー、観察，分析を通してレジリアンスの鍵となる要素を検討し，その要素を用いて地域の生態系と資源管理へのオプションを提示する。

3）領域プログラムにおける位置付け

本プロジェクトは「地球地域学」プログラムの構成員として、概念、方法、地域を主体にした学際的統合研究の開発・実施へ貢献している。プロジェクトメンバーが共有する概念はレジリアンス、方法はレジリアンスへの総合的アプローチ、地域は南部アフリカ・ザンビアの旱ばつ常襲農村地域である。レジリアンス研究は「地球地域学」プログラムが掲げる「地域の知」のみならず、地球研がキーワードとして掲げる「人間と自然の相互作用環」、「未来可能性」の実現に半乾燥熱帯地域の農村世帯のレジリアンスという具体的な事例で貢献するものである。

2. 全研究プロセスにおける本年度の課題と成果

1）本年度の研究課題

気象観測装置の準備・設置、試験圃場の整備、広域世帯調査を継続しながら、南部州・東部州の主要調査地にて、レジリアンスの要因に関する本格的な調査・観測を平成19年度11月の雨期から開始した。平成21年度は調査・観測を継続しながら、2年目2008/2009年農作期の観測データの収集・整理・分析を行う。

―ザンビア東部・南部州でそれぞれ実施している圃場試験において、メイズ収量の規定要因を明らかにする。
―2007年11月（2007/08年雨期の開始）より南部州のプロジェクトサイトで始めた家計調査，身体計測，降水量測定を継続し，一方で降水量変動によるメイズ生産の増減が家計消費や栄養状況に及ぼす影響の分析に着手する。さらに，農家圃場レベルの降水量変動とメイズ収量の関係を明らかにする目的で栽培試験を行う。
―農村部の脆弱性増大に関わる農村地域内生業(農業、林業、牧畜業)および村外経済活動(出稼ぎ、ネットワーク作り)に関する現地調査を継続し、さらに農村資源利用の根幹に関わる土地所有に関わる調査も実施する。
―南部州サイトにおいて2007年から2009年にかけて起こった環境変動に対する農民の生業活動の変化の時空間把握と、同地域・同期間における食糧援助活動の把握、さらにそれらの相互作用の検討を実施する
―南部州で実施されている調査グループの有機的な連携と統合を進める。
―レジリアンスに関する概念とレジリアンス解明に向けた作業仮説の整理を行う。

２）本年度に挙げ得た成果

平成21年度は順調に2年目の2008/2009年農作期の調査・観測を終え、3年目の2009/2010年農作期を迎えたところである。

―実証研究としてレジリアンスへどうアプローチするかをプロジェクト内で議論し、一定の方向性を決めた。昨年度の発表会以降、農村世帯の食料消費(food consumption)と生計(livelihood)が旱ばつや洪水等のショックから回復するメカニズムや速度を中心としてレジリアンスの研究を集約させることとした（図2)。具体的にはテーマ１ではメイズ収量から落ち込みの程度を把握し、テーマ２では食料消費・体重・皮下脂肪の回復からその速度を見る。テーマ３ではどう落ちたか、落ちないか、またどう回復したか、どのくらいの回復手段を持つかを定性的に解析し世帯間の違いを比較し、テーマ４では時空間的に見た農村世帯の資源利用の可視化を行なう。
―東部州の試験では、開墾に伴う土壌養分の放出様式や雑草の生育が耕作年数によって異なった。1年目に比べ2年目のほうが、養分がメイズ生育の初期から放出されたり、雑草の生育が旺盛であった。その結果、両者の効果が相殺され、最終的には1年目と2年目ではメイズ収量に違いが見られなかった。南部州の試験からは、圃場の地形上の位置によって、メイズ収量の年次変動のパターンが異なることが示された。多雨年に収量がよかった斜面上部の圃場に対し、斜面下部の圃場では多雨年には減収がみられたが通常年には高い収量を得た。
―2007/08年雨期は記録的な大雨であったが，圃場レベルの降水量調査より大雨の程度は家計ごとに異なることを明らかにし，さらに家計調査から大雨を受けた家計において食料消費が減少していることを明らかにした。身体計測からは，成人の体重の季節変動のパターンが確認された。
―昨年まで実施した地域内生業調査と村外経済活動、さらに土地所有に関する調査結果をワーキングペーパーとして発表した。また農村社会の脆弱性に関する文献調査も進め理論的整理も行った。
―2007/2008年雨季に起こった多雨とその被害への対処行動について、サイトA, B, Cそれぞれで空間的に被害状況を把握し、どの世帯に被害が大きかったか、もしくは、小さかったか、その地形的要因は何かを明らかにした。さらに、現地調査を基に、農業面では被害を受けた畑でのトウモロコシの再播種、サツマイモやマメへの作付け転換をおこなう、非農業面では家畜販売、漁業、短期的賃労働に出るなどアクセス可能な現金獲得活動をとるといった対処戦略(coping strategies)を世帯ごとで行なっていることを明らかにした。政府系の食糧援助の配布世帯の決定プロセスに関するローカルレベルのデータを入手し、世帯調査対象地（サイトA, B）におけるNGO（World Vision）の食糧と種子の援助配布対象者の特定を行うことができた。
―レジリアンス研究会を3回、ワークショップを今年度4回開催。8月28日に第2回ルサカ・ワークショップ“Towards Resilience of Rural Households in Drought-prone Areas”を開催し、ザンビア及び近隣諸国から多くの研究者、実務者、NGOの参加を得、農村社会のレジリアンスについての活発な議論を行った。3月1-3日に津波ワークショップをシンガポールで開催した。
―レジリアンス・ワーキングペーパー、007，008，009，010を刊行。またレジリアンス・アライアンスのレ

ジリアンス・ワークブックを日本語に翻訳し、プロジェクト HP へ掲載した。プロジェクト報告書(FS, PR, FR1, FR2, FR3)も掲載されている。http://www.chikyu.ac.jp/resilience/publication-W_e.html
—IHDP Open Meeting 2009 ボン大会（4 月開催）において、レジリアンスプロジェクトによる 2 つの企画セッション“Vulnerability and Resilience of Social-Ecological Systems in Rural Zambia”,“Vulnerability and Resilience in Coastal Zones”を実施し、8 名のプロジェクトメンバーが参加し研究成果を発表した。
日本学術会議 IHDP 分科会・小委員会へプロジェクトメンバー3 名が委員として参加することにより、国際的な研究コミュニティに参画する基盤を作った。

3.本年度の研究体制

1）研究体制

４つのテーマについて研究を実施し，世帯，地域レベルから歴史的，空間的分析などを相互にリンクさせる。特に自然科学分野の研究者との学際的研究により，科学的情報を社会科学の研究に応用できる研究者の参加を得ている。特に今年度は「概念、方法、地域」を主体にした統合に重点を置き、その方法等を検討し、会合も多く持った。研究や作業をスムーズに行うため必要に応じてワーキンググループ（WG）を作っている。現在までに作られた WG は、ワークブック翻訳 WG、気象ステーション WG、データ統合 WG, Sinazeze WG 等である。

予算はレンタカー費用の値上げにより調査費用が増加したため基本的に長期滞在を重点とし、また現地調査員の住環境を整備する等して観測体制の強化を行った。

ルサカ・ワークショップの参加希望者が多く、予算の見込みを上回った。

4.本年度の研究成果についての自己診断

1）目標以上の成果を挙げたと評価出来る点

—南部州の試験から、メイズ収量の規定要因として有効土層の厚さが重要である可能性を指摘できた。
—2007-2008 年の 2 年間の生業活動を世帯単位で調査・追跡することにより、多雨被害への対処戦略(coping strategies)を具体的に示したこと。サイト A・B における援助対象者の個人名を特定することができ、他の世帯調査やネットワーク調査との連携可能性が出てきた点。
—レジリアンスの概念や具体例についてルサカ・ワークショップの開催を通じて地元の研究者や実務者がザンビア社会を例として考える機会を提供することができた。

２） 目標に達しなかったと評価すべき点

—今年度はまだ終わっていないが，集中世帯調査は現時点までに 2008/09 年雨期のデータの分析に着手できなかった。
—農業、林業に加え調査対象地の農村部において重要な生業の一つである牧畜業に関するデータの整理が遅れている。

3）領域プログラムの研究戦略で得られた成果・課題

本プロジェクトは「地球地域学」プログラムの構成員として、概念、方法、地域を主体にした学際的な統合研究の開発・実施へ貢献している。レジリアンスは多様な撹乱やショックに対して柔軟に対応し、しなやかに回復し、システムが自ら変革していく能力を重視する広範な概念であり、地球環境問題に対する多くのアプローチへ貢献することのできる可能性がある。第 2 期中期計画のイニシアティブの展開にとっても重要なキーワードとなる。今後は地球研プロジェクトや他の研究機関との連携を深めていきたい。

5.昨年度発表会における質疑及び評価委員会コメントへの対応

昨年度のプロジェクト発表会からのコメントへの対応
―「レジリアンス」の概念とそのあり方を論じるための「指標」は何か？
レジリアンスは文脈の中で捉えなければならない。つまり、何のための、何に対する、何のレジリアンスであるかが重要となる。プロジェクトで考えるレジリアンスは、旱ばつや洪水などの気候の変動に対する、食料消費と生計のレジリアンスである。これは人間の安全保障が３つの生の中枢として考える生存(survival)、生計(livelihood)、尊厳(dignity) を守るためのものである。よって中心となるのは世帯の食料消費のレベルである。

―レジリアンスが高い状態とは何か？
プロジェクトが中心課題とする、すなわち食料消費と生計の回復から捉えた、レジリアンスとは、旱ばつや洪水のショックにより低下した食料消費とそれを支える農業生産と生計の回復がすみやかにできる世帯の能力である。コミュニティのレベルでは行政や NGO へのアクセスと交渉力なども重要である。一般論としてレジリアンスが高い状況とは１．多様性、２．生態的変動、３．Modularity ４．ゆっくりと変化する変数を大切にすること、５．堅固なフィードバック、６．社会的資本、７．革新、８、重層的ガバナンス、９．生態系サービス、等を備えた社会である。(Walker and Salt, 2006; Simon Levin, 2000)

―降雨量に対する農民の対応について
降水量については平年という表現は妥当ではなく、平均があるのみである。平年、旱ばつ年、洪水年という３つのフェーズで捉えているような印象を持たれたが、これは意図するところではない。たまたま初年度が洪水年であったという事実でしかないので、数年の観測を継続しない限り比較することは難しい。

評価委員会からのコメントへの対応
―長期の雨量データの分析が不足している
現地の長期観測は気象局の観測所と委託された voluntary station(VS)が実施しているが、現地観測を実施しながら、調査地に近い VS のデータやその他の雨量データも入手しつつある。

6. 来年度以降への課題

―レジリアンスの具体的な事例をフィールドの現場から考えることが重要である。
―世帯調査・身体計測のデータの質を向上させながら、データ整備を行うことが重要となっている。データの整備と同時にレジリアンスの要因の定性的・定量的解明を重点的に実施する予定である。
―来年度は気象観測、圃場実験、世帯調査を継続し、データを蓄積・整理・分析する予定である。
―特に１年目の 2007/2008 は洪水年であったが、2008/2009 年も比較的雨量は多かった。平均年の観測との比較が重要であるが、来年度は 2009/2010 年農作期のデータを分析し、3 農作期での比較を行いたい。
―地球地域学プログラムの課題のひとつに「調査地域住民への対応」があるが、調査世帯へのプロジェクトからの情報のフィードバック（雨量、身体計測）を可能な限り継続的に実施する。
―最終年度の国際シンポジウム、地球研フォーラムと出版に向けた研究計画を今年度中に作成し、具体的な作業ワークショップを開催する予定である。
―IRI 等の国際的な研究機関との連携：IHDP, Stockholm Resilience Center, IRI-Columbia Univ./NOAA 等の研究機関との連携を今後強めて行きたい。
―レジリアンスは広範な概念であり、地球環境問題に関する多くの研究課題を取り組むことができる。第 2 期中期計画のイニシアティブの展開にとっても重要なキーワードとなる可能性がある。今後は他のプロジェクトとの連携を強め、レジリアンス概念の応用可能性について所内外との議論を深めて行きたい。

7. 年次進行表

	H17 FS	H18 PR	H19 FR1	H20 FR2	H21 FR3	H22 FR4	H23 FR5
分析手法の確立	xxx	xx	xx	x			
ザンビア							
I. 生態レジリアンス	x	xx	xxx	xxx	xxx	xxx	x
II. 環境変動と農家世帯	x	xxx	xxx	xxx	xxx	xxx	x
III. 脆弱性と制度・歴史	xx	xx	xxx	xxx	xxx	xxx	xxx
IV. 広域と統合解析	x	xx	xxx	xxx	xxx	xxx	xxx
インド		x	x	x	x		
ブルキナファソ			x	x	x		
国際ワークショップ			x		x		x
報 告 書	FS 報告	PR 報告	年度報告	中間報告	年度報告	年度報告	最終報告

図１． 半乾燥熱帯と調査対象地域

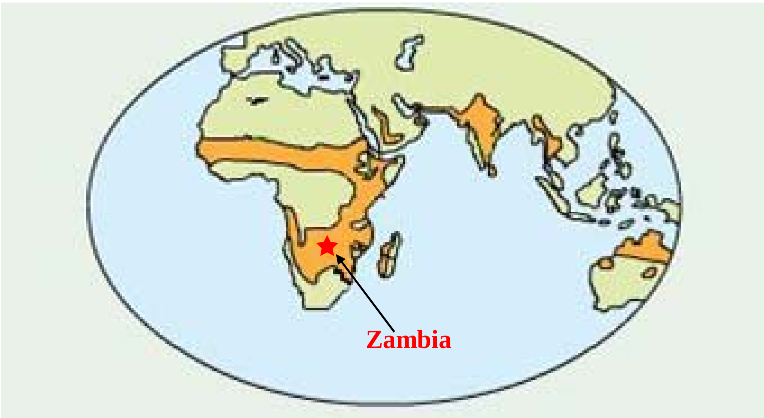
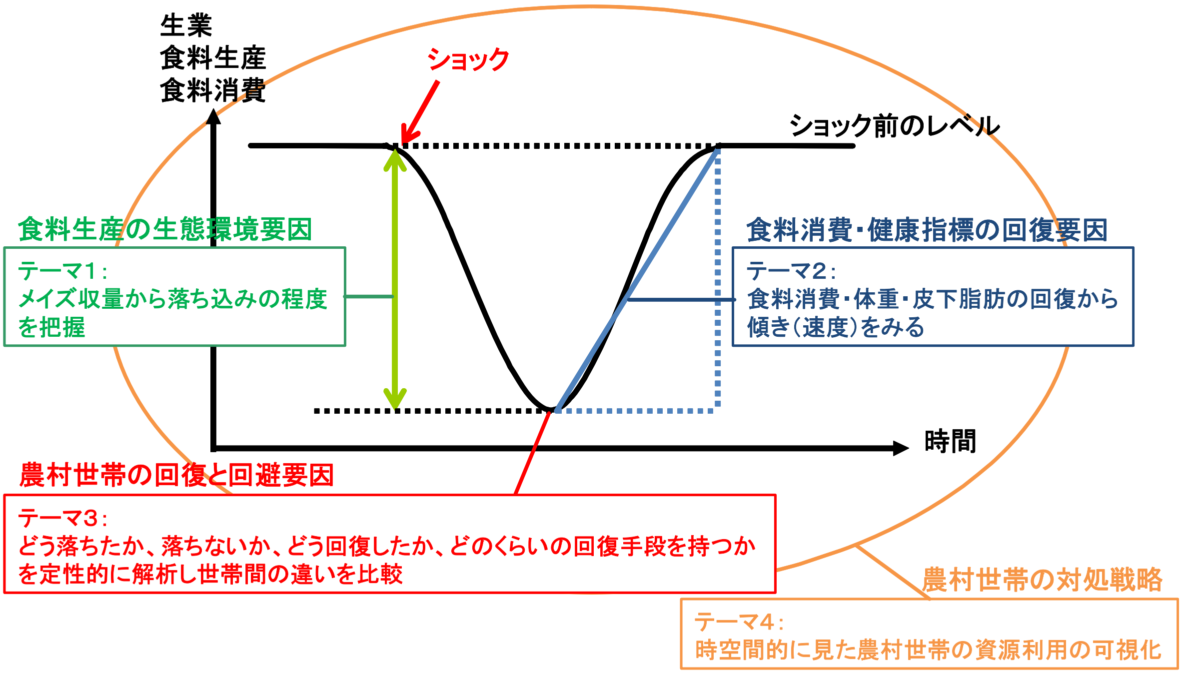


図２． レジリアンスへのアプローチ



E-04 (FR3) プロジェクトメンバー表 （平成21年度） 2010.2.7

	氏名	フリガナ	所属	サブ所属	職名	専門分野	役割分担
ﾘｰﾀﾞｰ	梅津　千恵子	ウメツ　チエコ	総合地球環境学研究所	研究部	准教授	環境資源経済学	地域経済分析・農村調査
A	谷内　茂雄	ヤチ　シゲオ	京都大学生態学研究センター		准教授	数理生態学	アドバイザー
	Theme I						
○	真常　仁志	ｼﾝｼﾞｮｳ　ﾋﾄｼ	京都大学大学院農学研究科	地域環境科学専攻土壌学分野	助教	土壌資源学	土壌有機物の分解・肥沃度測定
	安藤　薫	ｱﾝﾄﾞｳ　ｶｵﾙ	京都大学農学研究科	地域環境科学専攻土壌学分野	大学院生	土壌資源学	土壌有機物の分解・肥沃度測定
	柴田昌三	ｼﾊﾞﾀ　ｼｮｳｿﾞｳ	京都大学フィールド科学教育研究センター	上賀茂試験地	教授	森林生態	樹木構成種調査
○	田中　樹	タナカ　ウエル	京都大学大学院地球環境学堂	陸域生態系管理論分野	准教授	境界農学	土地利用とリスク管理の仕組み
	三浦励一	ミウラ レイイチ	京都大学大学院農学研究科	農学専攻雑草学分野	講師	雑草学	草本群落構成種調査
○	宮嵜英寿	ミヤザキ ヒデトシ	総合地球環境学研究所	研究部	プロジェクト研究員	土壌資源学	土地利用・履歴調査
	宮下　昌子	ﾐﾔｼﾀ　ﾏｻｺ	京都大学大学院地球環境学堂	陸域生態系管理論分野	大学院生	境界農学	土地利用とリスク管理の仕組み
○	Moses Mwale		Mt. Makulu Central Research Station, Zambia Agriculural Research Station	Ministry of Agriculture and Cooperatives	Vice Director	土壌学	土壌分析
	Theme II						
○	櫻井　武司	サクライ　タケシ	一橋大学経済研究所	日本・アジア経済研究部門	教授	開発経済学	農村世帯調査
	菅野洋光	カンノヒロミツ	(独)農業・食品産業技術総合研究機構　東北農業研究センター	やませ気象変動研究チーム	チーム長	気候学・農業気象学	気象観測
	下野　裕之	ｼﾓﾉ　ﾋﾛﾕｷ	岩手大学農学部	農学生命課程	准教授	作物学	作物モデル化
	山内太郎	ヤマウチ タロウ	北海道大学大学院保健科学研究院	保健科学専攻	准教授	人類生態学	成長、栄養状態と健康の評価
	今　小百合	コン　サユリ	北海道大学大学院保健科学研究院	保健科学専攻	大学院生	人類生態学	成長、栄養状態と健康の評価
	Theme III						
○	島田　周平	ｼﾏﾀﾞ　ｼｭｳﾍｲ	京都大学大学院アジア・アフリカ地域研究研究科	アフリカ地域研究専攻	教授	環境地理学	農村社会・制度調査
	荒木美奈子	アラキ　ミナコ	お茶の水女子大学文教育学部	グローバル文化学環	准教授	開発学	農村社会・制度調査
○	石本　雄大	ｲｼﾓﾄ　ﾕｳﾀﾞｲ	総合地球環境学研究所	研究部	プロジェクト研究員	生態人類学	救荒作物と農村世帯
	伊藤千尋	イトウ チヒロ	京都大学大学院アジア・アフリカ地域研究研究科	アフリカ地域研究専攻	博士課程	人文地理	農村の出稼ぎ労働
○	岡本　雅博	ｵｶﾓﾄ　ﾏｻﾋﾛ	総合地球環境学研究所	研究部	プロジェクト研究員	人類学、地域研究	農村社会・生業調査
	姜　明江	ｷｮｳ　ｱｷｴ	京都大学大学院アジアアフリカ地域研究研究科	アフリカ地域研究専攻	博士課程	緩和医療学	やまいの共生とケア
	児玉谷史朗	コダマヤ シロウ	一橋大学大学院社会学研究科	総合社会科学専攻	教授	アフリカ社会学	農業生産と社会変容
	成澤　徳子	ﾅﾘｻﾜ　ﾉﾘｺ	京都大学大学院アジアアフリカ地域研究研究科	アフリカ地域研究専攻	博士課程	ジェンダー人類学	農村女性の現金稼得
	半澤和夫	ハンザワ カズオ	日本大学生物資源科学部	国際地域開発学科	教授	農業経済	農村世帯調査
	Gear M. Kajoba		University of Zambia	Department of Geography	Senior Lecturer	地理学	土地制度と食料安全保障
	Chileshe Mulenga		University of Zambia	Institute of Economic and Social Research (INESOR)	Senior Lecturer	経済地理学	社会行動分析
	Theme IV						
○	吉村　充則	ﾖｼﾑﾗ　ﾐﾂﾉﾘ	(財)リモート・センシング技術センター		副主任研究員	リモートセンシング	生態変移モニタリング
	梅津　千恵子	ウメツ　チエコ	総合地球環境学研究所	研究部	准教授	環境資源経済学	地域経済分析・農村調査
	佐伯　田鶴	サエキ　タヅ	国立環境研究所	地球環境研究センター	NIESアシスタントフェロ	大気物理学	気候モニタリング
	松村圭一郎	ﾏﾂﾑﾗ　ｹｲｲﾁﾛｳ	京都大学大学院人間・環境学研究科	文化地域環境論講座	助教	文化人類学	農村社会と土地所有
	山下　恵	ヤマシタ　メグミ	学校法人　近畿測量専門学校		講師	地理情報学	植生モニタリング
○	Thamana Lekprichakul		総合地球環境学研究所	研究部	プロジェクト上級研究員	医療経済学	農村世帯調査・分析
	India						
○	K. Palanisami		International Water Management Institute	IWMI-TaTa Program	Program Coordinator	農業経済学	農村世帯調査・分析
○	久米　崇	クメ　タカシ	総合地球環境学研究所	研究部	プロジェクト上級研究員	土壌水文学	津波被害調査
	谷田貝亜紀代	ﾔﾀｶﾞｲ　ｱｷﾖ	総合地球環境学研究所	研究部	助教	気象・気候学	モンスーン降雨分析
	C.R Ranganathan		Tamilnadu Agricultural University	Department of Mathematics	Professor	数理モデル	社会経済モデル分析
	B. Chandrasekaran		Tamilnadu Agricultural University	Directorate of Research	Director	作物学	米作影響評価
	V. Geethalakshmi		Tamilnadu Agricultural University	Department of Agricultural Meteorology	Professor	農業気象学	モンスーン降雨分析
	Burkina Faso						
	Kimseyinga Savadogo		University of Ouagadougou	Department of Economics	Professor	経済学	家計調査データ分析
	Tom Evans		Indiana University	Department of Geography	Associate Professor	geography	agent-based modelling

○＝コアメンバー; A = アドバイザー

アフリカ農村世帯のレジリアンスへの序論

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はじめに

レジリアンス *resilience* はラテン語で「元に戻る」*resilire* という意味である。レジリアンスとはあるシステムがショックを受けた時に、同じ機能や、構造、フィードバックそしてアイデンティティを保持できるシステムの能力として定義される（Resilience Alliance 編　2007; 梅津・伊藤・真常・中村・松村・山下・吉村訳 2009）。レジリアンスとはまた、あるシステムが別のレジームへ変遷することなく安定状態を保ったまま許容できる攪乱（かくらん）の量を指す。レジリアンスを考える際に重要となる社会生態システムは、それを超えるとシステムの機能と構造を大幅に変化させてしまうようなある閾値をもっている。システムは、社会にとって意味のある時間のスケールでは不可逆なレジームシフトを経験することもある。レジリアンスの高いシステムとは、別のレジームへ遷移することなしにより大きな攪乱を吸収することができると考えられる(Gunderson 2003; Walker 2004)。

システム生態学者である C.S.Holling は 1973 年の論文、「生態システムのレジリアンスと安定性」によって生態学の概念としてレジリアンスを最初に提起した。初期のレジリアンス概念は「工学的レジリアンス」と呼ばれ、攪乱を受けた生態システムが、攪乱以前の初期の均衡に戻る回復時間として定義された。この定義では、回復時間が短いほど、攪乱に対する生態システムのレジリアンスは高いと考えられた。その後、工学的レジリアンスで考えられた生態システム単一均衡（安定点が 1 ヶ所であること）の概念は、非線形、複数均衡、レジームシフトなどの複雑系の概念を取り込みながら「生態的レジリアンス」として拡張された。1990 年代以降のレジリアンスの概念は、攪乱やショックを受けたシステムが自己再編成する能力をより重要視している。近年、社会科学の分野では、今まで生態学や工学の世界で主に使われてきたレジリアンスの概念を複雑な社会生態システムに応用しようとする試みが活発におこなわれている(Levin et al., 1998; Levin, 1999; Berkes, Fikret & Folke eds., 1998; Berkes, Colding & Folke eds., 2003)。特に旱ばつや洪水など災害からの地域社会の回復や、環境資源に生業を大きく依存する途上国の農村社会の発展を考える際に、レジリアンスの視点は極めて重要である。

生態的レジリアンスの理論は、1970 年代に盛んになったシステム生態学や、1980 年代後

半に設立されたエコロジー経済学の出現と時を同じくして発展した。エコロジー経済学は主に北欧や北米の先進諸国で発展したため、貧困や環境資源の荒廃などの途上国における重要な開発問題についての関心は非常に低かった。さらに、途上国経済を取り扱う既存の開発経済学の分野では、人間の経済活動の基盤となる生態サービスについてはほとんど対象としていなかった。そのため、環境資源の荒廃などが緊急の課題となっている発展途上国の問題を解決し、地域における人間の安全保障を高めるために、社会・経済分野の研究と生態学の研究をリンクさせ、レジリアンスの概念を発展途上国の社会・生態システムに応用する必要性が求められている。レジリアンスを考える重要な概念には、閾値、レジームシフト、冗長性などがある。

生態システムでのレジリアンス研究が先行したものの、社会システムの中でもレジリアンスを計量化するさまざまな方法がすでに試みられている。Briguglio (2005)は経済的レジリアンスを、1）ショックから素早く回復すること、2）ショックに耐えること、3）ショックを避けること、の 3 点で定義した。Briguglio は、マクロ経済安定性、ミクロ経済の市場効率性、良いガバナンス、の指標を使い、経済的レジリアンスの計量化による国別比較を実践した。Adger (2000)は社会的レジリアンスを「グループやコミュ二ティが社会的、政治的、そして環境の変化による外部からのストレスや攪乱に対処する能力」と定義している。Washington-Allen et al. (2008) はリモートセンシングのデータを使って乾燥地生態系の植物の生産性を計測し、生態レジリアンスの定量化を試みた。レジリアンスは社会経済的、生態的な意味で定義されてきたが、その実践的な評価はこれからの課題である。近年の国際開発分野でみられる新たな展開として注目されるのは、レジリアンスの概念を、資源に生活を依存する人々が多く暮らす地域の開発問題へ応用する取り組みが始まったことである(Mäler 2008)。2008 年に刊行された世界資源研究所・国連開発計画・国連環境計画・世界銀行の報告書「レジリアンスの根源―貧困層の富の拡大を目指して」Roots of Resilience-Growing the Wealth of the Poor（UNDP, UNEP, WB, WRI, 2008)の中では、地域コミュニティのレジリアンスを高めることが、地域開発の重要な目標のひとつとして提示されている。近年レジリアンス研究の発展(Resilience Alliance 2007)にもかかわらず、レジリアンスの評価は脆弱性の評価(Gallopin 2006)に比較するとまだ発展途上である。本稿ではレジリアンスプロジェクトが試みるレジリアンスへのアプローチについて概観する。

実践的なレジリアンスに向けて

半乾燥熱帯域（Semi-arid Tropics: SAT）(Thornthwaite 1948; Megis 1953; Troll 1965; Ryan and Spencer 2001)では、人々の農業生産は環境変動に対して脆弱である。サブサハラ・アフリカや南アジアの半乾燥熱帯では、世界の貧困人口の大部分が集中している。これらの地域では、農業生産は不安定な天水農業に依存している。天水農業に依存している。食料安全保障と貧困削減が重要な課題となっている。事前および事後のリスク対処戦略として、資源アクセスへの選択肢が多様であることがレジリアンスの重要な要素のひとつとなっている (島田, 2009; Thamana 2007)。資源へのアクセスは農業から牧畜、農業から非農業などさまざまな生

業形態間の生業の代替を通して行われる。また市場、社会的組織・制度などを介したり、社会的ネットワークも資源のアクセスには重要である。アフリカの農村世帯は、自然災害のリスクのみならず、社会経済リスクにもさらされている。グローバライゼーションによる換金作物の国際価格の変動、政治的な変遷、補助金や税金、土地所有制度や農業政策の変化など社会経済リスクへも対処しなければならない。

レジリアンスを実践的にするために、半乾燥熱帯域の農村世帯の人間の安全保障という文脈でレジリアンスを考えることが、重要と考える。レジリアンスプロジェクトでは、旱ばつ、洪水、そして社会変動などの環境変動に対するレジリアンスを考える。また食料供給、食料消費、健康状態、農業生産、生業*のレジリアンス*を考える。最後に、人間の安全保障—すなわち生存、生業、尊厳（人間の安全保障委員会事務局 2003）*のためのレジリアンス*を考える。

レジリアンスと「人間の安全保障」

「人間の安全保障」において鍵となる生存、生業、尊厳を基本にした半乾燥熱帯地域の農村世帯のレジリアンス（回復力）を考えてみると以下のようになる（図 1）。

生存　Survival

—（自給自足的農民にとって）世帯が生存を維持するために、食料消費と供給を旱ばつなどのショックからすみやかに回復させることの出来る能力。

生業　Livelihoods

—世帯やコミュニティが生活を維持するために、農業生産と生業を旱ばつなどのショックからすみやかに回復させることの出来る能力。農業生産の回復、他の生業への転換から得られる収入などによる世帯の生計の回復。

尊厳　Dignity

—世帯やコミュニティが個人の尊厳を損ねることのない生活環境を旱ばつなどのショックからすみやかに回復できる能力

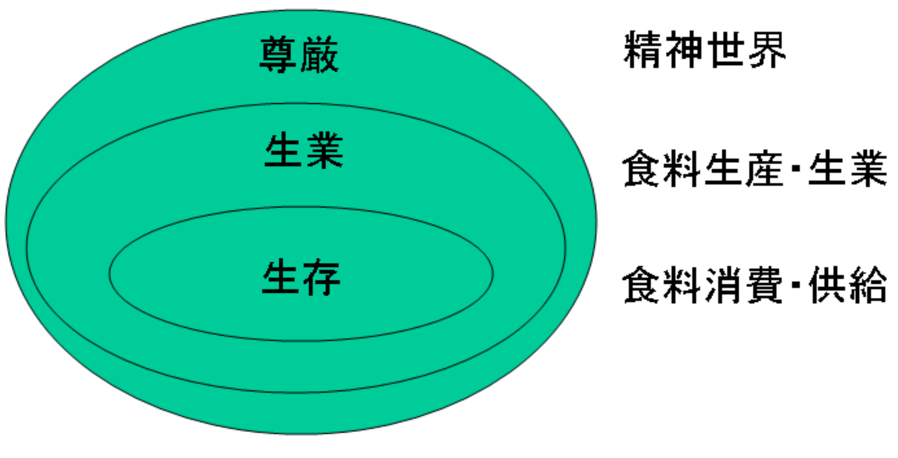


図1. 人間の安全保障のための生存・生業・尊厳

レジリアンスへのアプローチ

レジリアンスプロジェクトでは、4 つのテーマがさまざまなアプローチでレジリアンスを研究している。レジリアンスへの実証的なアプローチとしては、農村世帯の食料消費と生業が旱ばつや洪水等のショックから回復するメカニズムや速度を中心としてレジリアンスを研究する（図 2)。具体的にはテーマ 1 ではメイズ収量から落ち込みの程度を把握する(Shinjo et al.; 倉光他; Sokotela et al.; 宮嵜他 本報告書)。テーマ 2 では食料消費・体重・皮下脂肪の回復からその速度を見る(Sakurai et al.; Yamauch and Kon; Kanno et al.; Shimono et al. 本報告書)。テーマ 3 ではどう落ちたか、落ちないか、またどう回復したか、どのくらいの回復手段を持つかを定性的に解析し世帯間の違いを比較する(島田 2009; Ito 2009; 中村 2009; Kajoba 2009; Mulenga 2010; Ishimoto 本報告書)。テーマ 4 では時空間的に見た農村世帯の資源利用の可視化を行なう(山下・宮嵜・石本・吉村; 宮下他; Matsumura 本報告書)。また空間的レジリアンス(Evans and Caylor 本報告書)と、歴史的な変動に注目した調査(Thamana et al. 本報告書)も行われている。大規模な災害では、社会生態システムは別の状態へ移行する可能性もあり得る(Kume 2009; Palanisami et al. 本報告書)。

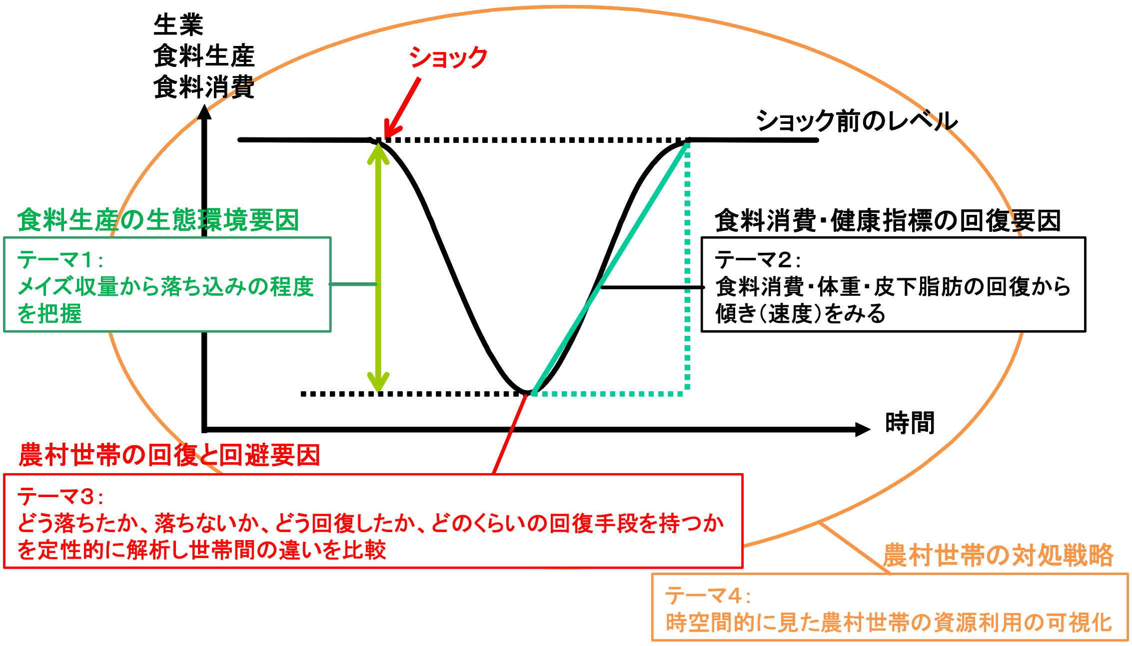


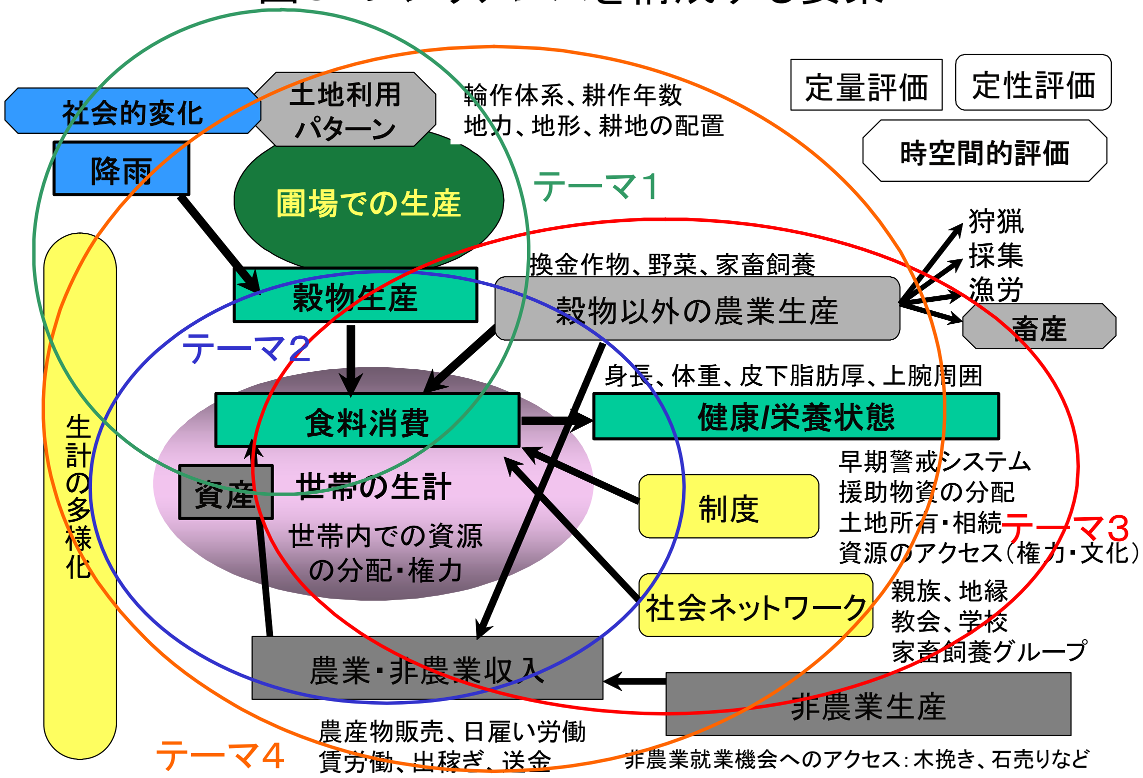
図2．レジリアンスへのアプローチ

レジリアンスの要素

旱ばつが起こった緊急時には、生存を維持するための食料確保が世帯とコミュニティにとっての最重要課題となる。半乾燥熱帯域の自給的農村世帯にとっての社会・生態システム

のレジリアンスとは、環境変動にたいする、人間の安全保障を守る生存・生業・尊厳のための、農村世帯の生存を維持する食料消費と、食料生産と生業のレジリアンスを考えることに他ならない。図 3 はレジリアンスプロジェクトの調査項目とレジリアンスの要素を示している。この図はまた旱ばつ常襲地帯での食料供給、食料消費、健康、生態系サービスの関係を示している。雨量や社会変動などの環境変動（何に対するレジリアンスかを示す）は青で示されている。レジリアンスの示標である食料供給、食料消費、食料生産、健康状態（何のレジリアンスかを示す）は緑で示されている。要素をつなぐ矢印はプロジェクトの作業仮説を示している。プロジェクトの目的は、レジリアンスの示標を検証することのみならず、この矢印の有無や強弱を明らかにすること、そして何がレジリアンスの要素や条件になっているのかを解明することにある。雨量の変動などによる環境変動によって、農民の農地からの収穫量が変動し、直接的に世帯の食料供給可能性と消費（生存）に影響を与える。食料消費が低下すると、それは世帯構成員の健康と栄養状態に影響をおよぼす。食料消費の低下の影響を特に強く受けるのは、5 歳以下の幼児であり、体重や皮下脂肪が減少や健康状態の悪化などによってその影響は身体に直接現れる。農地からの食料供給が低下した時には、世帯の家長は、あらゆる手段によって世帯のための食料を確保しようとする。その方策には、野菜など換金作物の販売、他の農業活動―狩猟、採集、漁業、牧畜等―への転換、などがある。もし食料を世帯へ供給するための農業生産が不十分な場合は、賃労働などの非農業活動に従事して食料を世帯へ供給し生計を維持する。援助機関の食料分配システム、資源へのアクセスを保障する地域の制度と組織のみならず、世帯の生存と生業の維持にとって、親戚や友人等の社会的ネットワークも

図3. レジリアンスを構成する要素



重要な役割を担っている。旱ばつ年に食料生産が低下したとしても、農村世帯はさまざまな対処戦略や代替の経済活動を駆使してショックから回復しようとする。加えて、地域レベルでの動態が生存と生業を維持するためにレジリアンスの源となる。生態系サービスはさまざまな資源を地域のコミュニティに供給する。例えば、農業生態システムは食料を供給し、湖沼生態システムは漁業資源を供給し、森林生態システムは救荒作物、エネルギーとしての薪、生活用水、建設資材などを供給する。

まとめ

本報告では、プロジェクトにおけるレジリアンスへの実証的なアプローチを概観した。半乾燥熱帯域の農村世帯の生業という文脈でレジリアンスを考える。対象となるのはザンビア南部の旱ばつ常襲地帯の農村世帯であり、彼らの生存と生業である。特に注目するのは、旱ばつや洪水など環境のショックを受けた後の食料消費、食料供給、そして生業の回復である。レジリアンスは自然資源管理に対する異なるアプローチへの扉を開く可能性を持つ概念である(Resilience Alliance 2007)。農村社会の持続性にとって個々の世帯のレジリアンスはその地域コミュニティ全体のレジリアンスの基盤となる。レジリアンスとはさまざまなレベルでの持続的な社会を構築するための社会の基本的な能力である。

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ザンビア東部州ミオンボ林において
開墾・火入れが作物生産と土壌肥沃度に与える影響

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ザンビア東部州のミオンボ林において、開墾に伴う土壌肥沃度や作物生育の経時的変化を降雨の年次変動と区別して評価できるような野外実験を実施しているところであり、これまでに得られた結果を報告する。

ザンビア東部州では開墾の際火入れを行うが、木本バイオマスが少ないため高木に低木を積み上げた箇所にのみ火が入る。従って当地域で森林開墾後の耕作による土壌養分や作物生育の変化を知るためには、火入れの有無を考慮した耕地全体の評価が必要である。また高木と低木を積み上げず、分けて火入れをすることで、その面積を拡大させれば収量が増加する可能性がある。そこで本年は森林開墾後の耕作が土壌養分・作物生育に与える影響を、1．燃やすバイオマス量、2．火入れの有無と耕作年数の違い、に着目し評価した。

耕作 1 年目の火入れ区で、土壌は燃やすバイオマス量による影響を受け、高木下の土壌は低木下の土壌より温度が下層まで上昇し、それに伴い無機態窒素量・可給態リンの増加が見られた。灰によるリンの顕著な増加も認められた。燃やすバイオマス量で収量に変化はなく、高木・低木を分けることで火入れ面積が拡大したことから畑地全体では収量は増加した。

耕作 2 年目の火入れ区で土壌中の無機態窒素量は 1 年目より減少したが、耕作 2 年目の火入れなし区よりも高かった。可給態リンは火入れ区の耕作 1 年目・2 年目で変化せず、依然高い値を示した。収量はこれを反映し、2 年目の耕作で収量は 1 年目より減少するものの火入れなし区より依然高く、火入れによって少なくとも 2 年間増収することがわかった。火入れなし区では土壌の中の窒素無機化量・可給態リン量が 2 年目に増加したにもかかわらず収量は増加しなかった。2 年目で雑草量がトウモロコシ生育後期に増加したため、収量増加がみられなかったと考えられる。

ザンビア東部州における土壌肥沃度回復と持続的農業推進のためのアグロフォレストリーの評価
-2008/09 年作季の進捗報告-

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１．で報告した野外試験地に隣接する圃場において、土壌肥沃度の回復のためのアグロフォレストリー種の展示と評価を実施している。候補となる種として *Grilicidia sepium*、*Mucuna repensis*（ハッショウマメ）、*Cajanus cajan*（キマメ）を 2007 年より栽培している。いずれもマメ科であり、窒素固定による土壌肥沃度の向上が期待される。高さや基部直径の測定のほか、生育状態を目視により観察したが、特に目立った生育の遅滞は認められなかった。さらに、当試験を実施している村の農民のほか、近隣村の村長 10 名程度、チーフ代理、改良普及員を招いて圃場試験の様子を公開した。キマメに興味を持った村長が多く、後日収穫したキマメの種子を参加した村長数名に配布した。

家計および個人レベルのレジリアンスの実証
-ザンビアの旱魃常襲地帯における豪雨の事例-

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要旨

発展途上国の農村部では人々の生計が常に様々なリスクに脅かされているため、リスクへの対応や消費の平準化に関して膨大な量の実証研究が存在する。“対応”にはショックからの回復のプロセスという意味を含むが、既存の研究は家計や個人の消費水準が回復するのに要する時間は考慮していない。そのため、ショックの厚生水準へのインパクトが過小評価されてしまうという問題がある。なぜなら、ショック後でデータ収集を実施するより前に消費の回復が始まってしまうと、ショック（つまり消費の減少）と回復（つまり消費の増加）が区別できないからである。

既存の研究の欠点を克服するために、この論文はショックからの回復プロセスに時間の次元を導入する。その目的で、この論文は生態学におけるレジリアンスの概念を取り入れ、消費平準化という文脈においてレジリアンスを定義した。さらに、消費平準化について今までに実施されたほとんどの研究と異なり、この論文は、同時発生ショックの事前と事後に集めた週次データを利用することでレジリアンスの実証を行う。

この論文ではまず、家計レベルおよび個人レベルの“レジリアンス”について、実証研究に用いることのできるような定義を与えた。家計レベルでは、家計の 1 人当たりの食料消費に基づき。ショックから食料消費水準が回復する速度によりレジリアンスを定義する。一方、個人レベルでは、レジリアンスの計測に体重を用い、ショックから体重が回復する速度としてレジリアンスを定義する。

次に、この論文は、我々自身がザンビアの南部州で集めたデータを使って、レジリアンスの実際の計測方法を示した。ザンビア南部州は同国の中でももっとも旱魃の被害を受けやすい地域である。ところが予想に反して、現地調査を開始した直後の 2007 年 12 月に調査地では希なほどの豪雨が発生した。この豪雨は畑の作物に被害を与え道路や橋などのインフラストラクチャーを破壊したので、調査地の家計や個人にショックをもたらしたと考えられる。分析ではサイトＡとサイトＢを比較した。通常年ではサイトＡの方がサイトＢより降水量が少なく旱魃が起こりやすい。しかし、2007 年 12 月の豪雨は両サイトに同じように起こった。にもかかわらず、サイトＡでのみ顕著な食料消費と体重の減少が観察され、2 つの指標が元の水準にまで回復するには数ヶ月を要した。定義に従い、サイトＡの家計と個人の方が、サイトＢの家計と個人よりもレジリアンスに欠けていると結論できる。

ザンビア共和国南部州の異なる生態学的環境に暮らす成人男女の栄養状態の変動
—16ヶ月間の身長、体重、BMI—

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要旨

昨年度のプロジェクト報告書において、下部平原地の居住者（成人男女）は中間傾斜地および上部平原地居住者に比べて身長が高く、また体重も重いことを報告した（Yamauchi, 2009)。本稿では 2007 年 11 月から 2009 年 2 月に至る、のべ 16 ヶ月間の身体計測データを元に、生態学的に異なる 3 地域（上部平原地、中間斜面地、下部平原地）に居住する成人男女の体重とボディ・マス・インデックス（BMI = 体重[kg] ÷{身長[m]}²）の月ごとの変動について報告する。

性、地域によらず、体重と BMI に共通した変動パターンが見出された（減少→増加→減少)。この結果は、地域住民の体重および BMI は、気候変動（とくに降雨量）や農業サイクルと密接に関係していることを示唆している。さらに興味深いことに、男性と女性の体重および BMI の変動パターンは酷似していたことが分かった。同じ地域に居住する成人男女の食物摂取や身体活動のパターンは類似している可能性が示唆される。

冒頭で述べた昨年度の報告書の結果と同様に、16 ヶ月間通してみても下部平原地に暮らす成人は、男女ともに他の 2 地域の男女より体重が重かった。しかし、下部平原地の男性の BMI は 3 地域で最低値であった。これは同男性の身長が 3 地域では一番高かったためである。また BMI の性差において、3 地域で特徴的な違いがみられた。下部平原地では BMI の性差は 3 地域の中で最も大きく、中間傾斜地では BMI の性差は縮まり、上部平原地では性差はほとんどみられなかった。 3 地域では性による労働内容や分業の程度が異なっているのかもしれない。食物の利用可能性や食糧の分配の性差なども BMI の性差に影響を与えている可能性が考えられる。

本研究で見出された興味深い知見の背景にあるメカニズムを解明するために、体重および BMI と月ごとの気候変動（降雨量）や食物生産・消費の変動との関係について探求する必要がある。さらに、地域住民を対象として、食事調査や行動観察、エネルギー消費量測定を実施することが望まれる。

文献

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ザンビア、シナゾンウェにおける 2008/2009 年雨季の気象観測解析

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要旨

2007 年 9 月から、ザンビアのシナゾンウェ州にて気象観測を開始し、今年度は 2 シーズン目の雨季データを取得することが出来た。2008/2009 年雨季について、気象観測ロボット 2 台（サイト A、C）は 11 月上旬から観測を開始した。今季は 2 観測点とも、相対湿度が取得でき、混合比・相当温位を用いた比較解析が可能になった。風向に関しては、4 月に点検したところ、ゆるみ等で正常な値が測定できていない可能性があり、図は作成しなかった。

雨量計に関しては、2008 年 10 月から観測を開始したが、今季はトラブルが多く（データロガーの水没や雨量計の穴の詰まりによると思われる欠測等）、2009 年 4 月末まで正常なデータが取得できたと思われるのは、サイト A で 4 地点、B で 6 地点、C で 9 地点であった。2007/08 年雨季と比較するため、2 回の雨季を通して正常にデータを取得していた地点数を確認したところ、サイト A では最小の 3 地点であった。3 つのサイトで母数を合わせるため、各サイト 3 地点分を平均し、サイトの値とした。

雨量については、サイト A で昨年と今年の雨季の差が大きく、247mm に達したのに対し、サイト C ではその差が 28mm と小さかった（気象ロボット）。サイト B では 241mm と A と同程度に大きく、高地（C）のみ年々の変動が小さい。時間雨量をみたところ、23 時～1 時の夜間に降水が多い日変化が明瞭であった。

気温はサイト A がサイト C よりも 3℃程度大きい。両地点間の気温減率を見ると、2007/08 年雨季の方が 2008/09 年雨季よりも大きく、対流が不安定であった可能性がある。

日平均風速は、サイト A で雨季間の差が大きく、サイト C で小さい。2007/08 年雨季には、サイト A で雨量・風速ともに大きく、雨季間で総観スケールの違いがあった可能性がある。

日射量は、12 月下旬～1 月上旬で両雨季の差が大きく、2007/08 年雨季で値が小さい。降水量を増加させた明瞭な降水システムを反映していると考えられる。

最後に、湿度についてみると、3 月下旬の絶対湿度の不連続的な低下が特徴的である。この時期、日射量も 2 雨季を通じて減少しており、前線帯の季節移動に伴って気団の入れ替わりがあったこと、それは毎年ほぼ同じ時期である可能性があること等が示唆される。

ザンビア南部州のトウモロコシの生産性に作期移動が及ぼす影響

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要旨
ザンビア南部州のトウモロコシの生産性に作期移動が及ぼす影響を 2008/09 年に評価した。いずれの地点でも作期を遅くすることで収量の低下が認められたが、その程度がＢ地点とＣ地点でＡ地点より大きかった。両地点では播種から開花までの日数が、作期を遅くすることで延長が認められた。

1. はじめに

地球温暖化に伴う気候変動、特に降水パターンの変化がザンビアの主食であるトウモロコシの生産に及ぼす影響が懸念されている。本研究では、雨季の開始時期の判断がトウモロコシの生産性に及ぼす影響を評価するため、降水パターンに変異のある高度の異なる３地域においてトウモロコシを栽培し生産性への影響を評価した。

2. 材料と方法

トウモロコシのザンビア在来品種 Jileile を高度の異なる３つの地域（標高の低い順からＡ、Ｂ、Ｃ、Ａ地点 = Sianemba 村 と Siameja 村、Ｂ地点 = Chanzika 村、Ｃ地点 = Siachaya 村における計６つの異なる圃場、第１表）の 2008/09 年のシーズンに２～３作期で栽培した（栽植密度 3.3 本/m^2)。対照区（11 月下旬～12 月上旬、第１表）を基準に 10 日、20 日作期を遅らせる試験区を設置した。栽培は施肥、薬散等は行わない現地の慣行法に沿った。除草は適宜、実施した。各試験区のサイズは対照区が 20m×20m、作期移動区が 10m×20m とした。出芽日、開花日を調査するとともに、収穫期（3 月下旬から 4 月上旬）に子実収量（70℃乾燥）を調査した。Ａ地点とＣ地点では降水量、日射量、気温、風速を計測し、Ｂ地点については気温のみを計測した。

3. 結果と考察

１） 生育期間中の気温をみると、最も標高の高いＣ地点では、標高の低いＡ地点に比べて降水量は 14％多く、気温が 3.8℃低く、日射量が 10％少なく、風速は 63％早かった（第１表）。

２） 開花日は、対照区では気温の低いＣ地点がＡ、Ｂ地点より遅くなり、播種から開花までの日数が延長した（第２表）。作期を遅くすると、その播種から開花までの日数はＡ地点では変化がみられなかったが、Ｂ、Ｃ地点では延長した。

３） 子実収量は、対照区においてＡ地点、Ｂ地点では 100g m^{-2} 以上であったが、Ｃ地点では 30g m^{-2} 以下と低かった（第３表）。この地点間の子実収量の違いは、苗立本数より個体あたりの子実重に依存した。作期の効果をみると、Ａ地点では作期の効果がみられなかったが、Ｂ地点とＣ地点については、作期を遅くすることで大幅に低下し

た。子実収量の低下程度と播種から開花までの日数の延長程度の間には密接な関係が認められた（R^2=0.84）。また、子実収量の低下程度と気温との間でも関係が認められた。

4）　以上、2008/09 年の気象条件かつ作期の範囲では、いずれの地点においても通常の植え付け時期が最も高い収量性を示し、その妥当性が明らかとなった。その一方で、Ｂ、Ｃ地点においては、逆に植え付け時期を早めることで収量増加の可能性が示唆された。

第1表　ザンビアのトウモロコシ生育中の気象条件(12月～3月)(2008/09)

項目	A地点	B地点	C地点
緯度	17°　05'S	17°　05'S	16°　59'S
経度	27°　30'E	27°　20'E	27°　20'E
標高	517 m	769 m	1075 m
日平均気温(℃)	25.6	23.0	21.8
日射量(MJ)	22.3	−	19.9
降水量(mm)	953	−	1087
風速(m/s)	0.8	−	1.2

第2表 作期がザンビアのトウモロコシの発育ステージに及ぼす影響(2008/09)

地点	農家番号	処理	播種		出芽		開花		播種から開花まで日数	
A	ASn1	対照区	4-Dec		7-Dec		30-Jan		57	
		10日区	13-Dec	(+9)	17-Dec	(+10)	7-Feb	(+8)	56	(-1)
		20日区	23-Dec	(+19)	27-Dec	(+20)	19-Feb	(+20)	58	(+1)
	ASm2	対照区	4-Dec		-		30-Jan		57	
		10日区	13-Dec	(+9)	-		-		-	-
B	BCh2	Control	29-Nov		-		17-Jan		49	
		10d later	8-Dec	(+9)	-		5-Feb	(+19)	59	(+10)
C	CSa1	対照区	28-Nov		-		2-Feb		66	
		10日区	7-Dec	(+9)	13-Dec		27-Feb	(+25)	82	(+16)
		20日区	17-Dec	(+19)	23-Dec		20-Mar	(+46)	93	(+27)
	CSa2	対照区	28-Nov		-		2-Feb		66	
		10日区	7-Dec	(+9)	13-Dec		27-Feb	(+25)	82	(+16)
	CSa3	対照区	28-Nov		-		1-Feb		65	
		10日区	7-Dec	(+9)	13-Dec		27-Feb	(+26)	82	(+17)

カッコ内は対照区からの差を示す。

第3表 作期がザンビアのトウモロコシの収穫期の子実収量，苗立ち本数，個体子実重に及ぼす影響(2008/09)

地点	農家番号	処理	子実収量 g m^{-2}			苗立本数 m^{-2}		個体子実重 g 個体$^{-1}$	
A	ASn1	対照区	116	±11		2.7		43.2	
		10日区	121	±21	(1.04)	3.0	(1.12)	40.2	(0.93)
		20日区	121	±11	(1.05)	3.8	(1.40)	32.4	(0.75)
	ASm2	対照区	112	±14		2.4		47.1	
		10日区	74	±16	(0.66)	4.5	(1.90)	16.4	(0.35)
B	BCh2	Control	196	±17		2.5		79.6	
		10d later	137	±26	(0.70)	3.0	(1.22)	45.8	(0.58)
C	CSa1	対照区	20	±7		2.3		8.7	
		10日区	1	±1	(0.05)	2.6	(1.16)	0.4	(0.04)
		20日区	0	±0	(0.00)	1.8	(0.77)	0.0	(0.00)
	CSa2	対照区	25	±5		1.7		14.8	
		10日区	14	±7	(0.55)	3.4	(1.98)	4.1	(0.28)
	CSa3	対照区	29	±9		1.9		15.2	
		10日区	3	±1	(0.09)	3.4	(1.82)	0.7	(0.05)

カッコ内は対照区に対する比率。子実収量 ± 標準誤差 (n =12　対照区, n = 4 10日区，20日区)。

ザンビア・トンガ人社会における保険としての社会ネットワーク
-第 1 報-

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要旨

本研究では、社会ネットワークによる保険として世帯間のサポートに注目し、日常的サポートと臨時的サポートの 2 つに分け分析を行った。日常的サポートのうち、食料生産および食料消費における共同労働メンバーは、①いずれの活動とも近い血縁者が多いこと、②構成員の家屋は物理的に近いこと、③構成員は重複することが多いこと、④畜力利用はメンバー形成に大きな影響を与えることが明らかになった。臨時的サポートのうちモノの贈与は、①頻度および量が農作業の進行状況に伴い変化すること、②季節変化があること、③立地条件によっても傾向が変化することが明らかになった。

1. はじめに

半乾燥熱帯(SAT)の農村部に暮らす人々の家計は、生態環境による影響が大きく、農業生産量および所得が大きく変動する。SAT に位置するザンビア南部州で同様の生活を送るトンガの人々は保険市場や公的社会制度へのアクセスが困難な状況下で生活している。本研究の目的は、社会ネットワークが保険としていかに機能するかを解明することである。ただし、調査は現在も継続中であり、本研究は予備的報告である。

2. 調査概要

調査地は、ザンビア南部州シナゾングウェ地域[1]の低平坦地に位置するサイト A、中間の傾斜地に位置するサイト B、高平坦地に位置するサイト C であった。いずれのサイトにおいても住民の大部分はトンガの人々であった。

調査方法は直接観察およびインタビューであり、一部は質問票を用いて調査対象者自身に記帳を依頼している。主な調査項目は、生業活動、食事といった日常生活における活動の構成員、モノ・金・行為のやりとりの量である。

3. 世帯間で機能する保険 -日常的サポート-

本研究では、社会ネットワークによる保険として世帯間のサポートに注目する。ここでは日常的サポートと臨時的サポートの 2 つに分け分析を行っていく。3 章では日常的サポートを考察するため、食料生産活動、消費活動におけるメンバー構成を調査した。メンバー間の関係やその背景（血縁関係や居住地など）を分析する。

3.1 食料生産活動

本研究では、食料生産活動における日常的サポートを分析するために農耕および家畜飼養における共同作業の構成員に注目した。

作業により共同作業の行われる割合は異なるが、メンバー構成は重複していた。メンバー数が農作業で最も多い耕起作業、家畜飼養において最も多い牛放牧とは、特に重複している。この重複は、牛なし世帯が牛を借りるために、耕起作業や牛の放牧を手伝うので生じる 。すなわち、畜力の利用が、メンバー拡大の契機となっている。

3.2 食料消費活動

食料消費活動に関しては、共住と共食のメンバーシップについて分析を行った。
他の世帯と共に食料消費活動を営む割合は、サイト A で高く、サイト B で低かった。これは家屋の密集度と関係があると考えられた。また、共住世帯は共食をするが、共住していない世帯同士が共食を行うこともあることが明らかとなった。

3.3 日常的サポートの背景

日常的サポートの背景を理解するため、食料生産および食料消費における共同労働メンバー間の関係について比較分析を行った。①いずれの活動とも近い血縁者が多く、②構成員の家屋は物理的に近く、③構成員は重複することが多いことが明らかになった。ただし、一部の世帯では牛の欠如・不足が原因で、生産と消費の構成員は重複しない。すなわち、④畜力利用はメンバー形成に大きな影響を与えている。

4. 世帯間で機能する保険 －臨時的サポート－

モノの授受は不定期に行われる。これらは、贈与、売買、貸借および労働への報酬などがある。本研究では、臨時的サポートとして贈与に注目する。季節、立地がもたらす影響に関して、世帯 E および F の 2 つの事例研究をもとに分析を行った。

4 章からの主な知見は以下の 3 つである。①贈与の頻度および量は農作業の進行状況に伴い変化する。それは、農耕が大部分の人々の主生業であるためである。従って、②贈与の頻度および量には季節変化がある。贈与は、播種期および収穫期に多い。③立地条件によっても贈与の傾向は変化する。特に、乾季畑に適した土地の有無は、それによって農耕期間に違いが出るため、贈与の傾向に強い影響がある。

今後は、居住地の距離および血縁関係の近さとモノのやりとりの関係について分析を進めていく。

2007/2008 の多雨による作物被害への対処行動にみられるレジリアンス
－南部州・シナゼゼ対象地域における現地調査より－

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１．はじめに

筆者らは、南部州のシナゾングウェ地区に設置した 3 サイト A/B/C（計 5 ヵ村）において、村人の生業活動を村落レベルから地域レベルに渡って時間的空間的に追跡することを目的とし、現地調査から空中写真・衛星画像までの異なる空間スケールデータを時系列で収集している。収集した各種データは、位置情報を介して GIS 上で統合し、干ばつや多雨・洪水などの環境変動への対処行動に関する分析や、土地利用／土地被覆の季節変化・経年変化解析に用いている。

本報告では、2007/2008 年雨季および 2008 年乾季に耕作地として利用された土地を GPS で測定し作成した作物別耕作地マップと現金獲得状況の聞き取り調査結果を用いて、2007 年 12 月の多雨による作物被害状況および村人たちの対処行動について分析した結果の一例を紹介する。対象領域は、カリバ湖畔に近い低地から、丘陵地、標高 1000m 以上の高地までの異なる地形上に位置するサイト A/B/C の 5 ヵ村（ASm, ASn, BCh, Bka, CSa）で、2007/2008 年における調査世帯数は、5 ヵ村で約 200 世帯ある。

２．多雨による雨季畑の被害状況

多雨による作物被害があった 2007/2008 年の年間降雨量は、サイト A で 1441.6mm/yr、サイト C で 1332.1mm/yr であり、シナゾングウェ地区の長期平均降雨量 694.9mm/yr と比べて約 2 倍もあった。表 1 は、同年に作付けられた全雨季作トウモロコシ畑に対する多雨の被害面積割合を作物別耕作地マップより 5 ヵ村別に集計した結果である。サイト A・B では、25～40％の割合の畑が被害を受け、サイト C では約 4％の被害であった。

図 1 は、3 サイト内で被害割合が少なかったサイト C の CSa 村における雨季畑と被害畑の分布を示す。緩やかな起伏のあるサイト C では、被害畑は、小さな河川および谷部に集中していることが分かる。多雨により畑が冠水したことで発芽しなかったことが、被害の原因となった。図 2 は、サイト C における多雨の被害を受けた後の作付状況を示した分布図である。サイト C では、被害後の対処として、耕作を放棄、あるいは、新たにサツマイモの作付されていることが分かる。

３．多雨被害後の農耕における対処行動

図 3 は、トウモロコシ畑における多雨被害後の栽培作物面積の割合をサイト A/B/C の 5 ヵ村別に示したものである。ASn 村を除く 4 ヵ村では、多くの被害畑の内、約 6～9 割近くが耕作放棄されていることが分かる。ASn 村では、8 割の被害畑にトウモロコシを再播種している。その他、ASm 村では主にガーデン、BKa 村ではラッカセイと乾季トウモロコシ、CSa 村ではサツマイモへの作付転換によって対処されていることが分かる。

図 4 は、被害面積割合が最も大きかったサイト A（ASm・ASn 村）における雨季畑と多雨による被害畑の分布図である。フラットな地形を呈しているサイト A において、多雨による被害畑は、航空写真を用いて立体視したところ、他の土地と比べて僅かながら低くなっており、水はけの悪い条件であることが考えられる。図 5 には、多雨被害後の作付状況を示す。サイト A 全体の被害面積割合は約 34%であるが、世帯別にみると、まったく被害を受けていない世帯もあれば、100%に近い被害を受けた世帯もあり、多雨による被害には、世帯間の差が大きく見られた。このように被害割合の大きい世帯については、農耕以外の対処行動により回避していることも考えられる。

４．多雨被害後の非農耕における対処行動

表 2 は、サイト A の対象世帯の内、8 割以上の雨季畑が多雨の被害にあった世帯について、2007 年度と 2008 年度の現金獲得状況を示す。表の数値は、各世帯の全現金収入を 100 とした割合（%）である。2007 年度は、トウモロコシ・コットンの売却による現金獲得割合が多いのに対し、2008 年度では、トウモロコシの売却が急激に減っており、多雨被害の影響が表れている。多雨被害の翌年には、どの世帯も、家畜の売却や漁業、短期賃労働などによって現金を獲得し、多雨の被害を回避していることが分かった。

５．まとめ

サイト A,B,C それぞれで 2007/2008 年雨季に起こった多雨の被害状況を空間的に把握した結果、フラットな地形のサイト A では水はけの悪い畑、斜面勾配が急な丘陵地形のサイト B では斜面の畑、緩やかな起伏のあるサイト C では谷部の畑において、多雨の被害が集中していることが分かった。

また、多雨による作物被害への対処行動として、サイト C の調査村では、被害地にサツマイモを積極的に作付して回避していることが分かった。サイト A の調査村では、25～40%の多雨被害地に対して、耕作放棄の他、トウモロコシの再播種が多くみられた。中でも、8 割以上の被害を受けた世帯については、非農耕による対処として、家畜売却・漁業・短期賃労働等の現金獲得により回避していることが分かった。さらには、今後の継続的調査・分析によって、親族・隣人ネットワーク内での労働力や食料の授受等による対処行動についても明らかになりつつある。

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表１．　2007/2008 年における全雨季作トウモロコシ畑のサイト別被害面積割合

Site	Village	Rainy Maize(ha)	Damaged area (ha)	Ratio (%)
siteA	ASm	31.98	8.31	26.0%
	ASn	33.83	13.74	40.6%
SiteB	BCh	37.17	11.49	30.9%
	BKa	40.84	10.49	25.7%
SiteC	Csa	113.84	4.11	3.6%
	total	257.66	48.14	18.7%

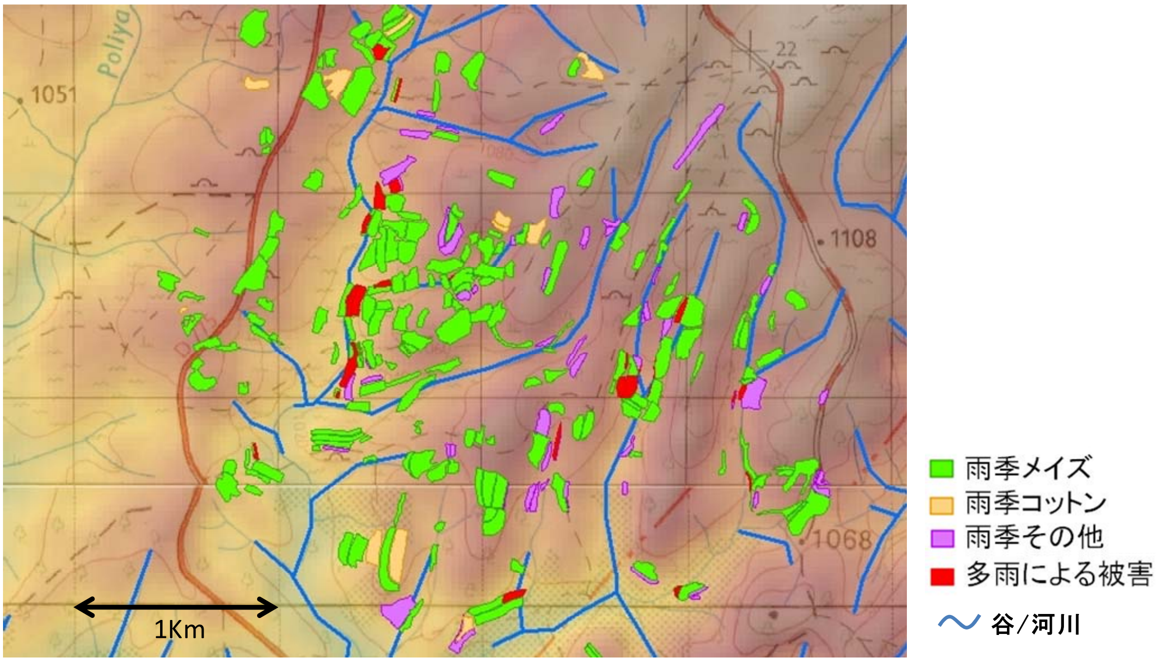

図１．　サイト C（CSa 村）における雨季畑と多雨による被害畑の分布

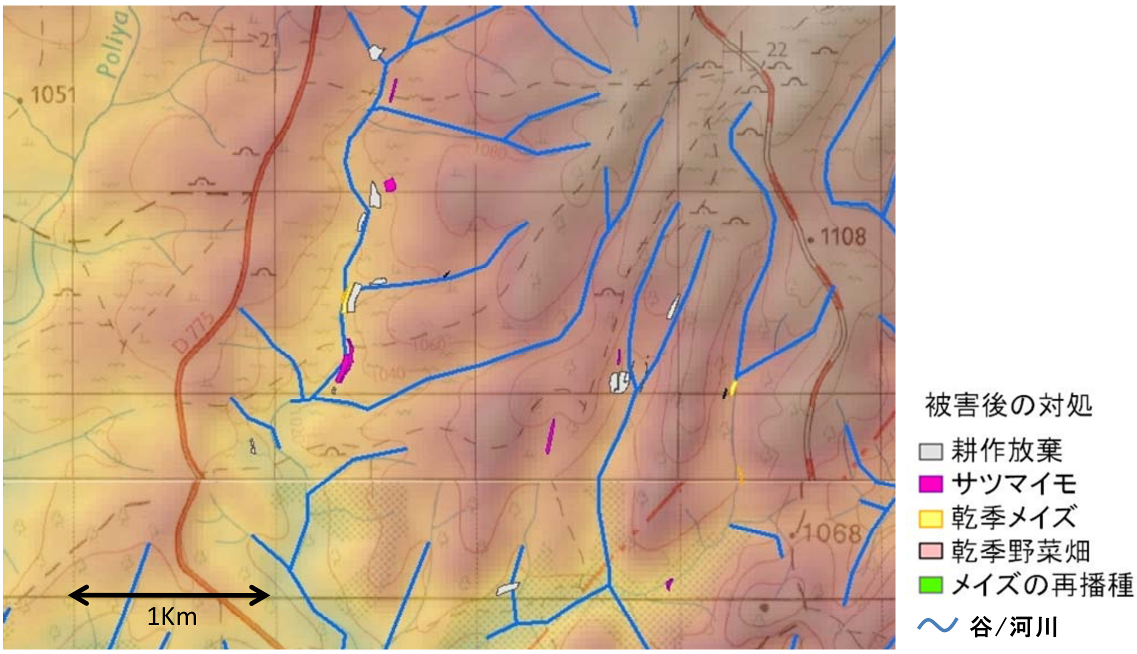

図 2.　サイト C（CSa 村）における多雨被害後の作付状況

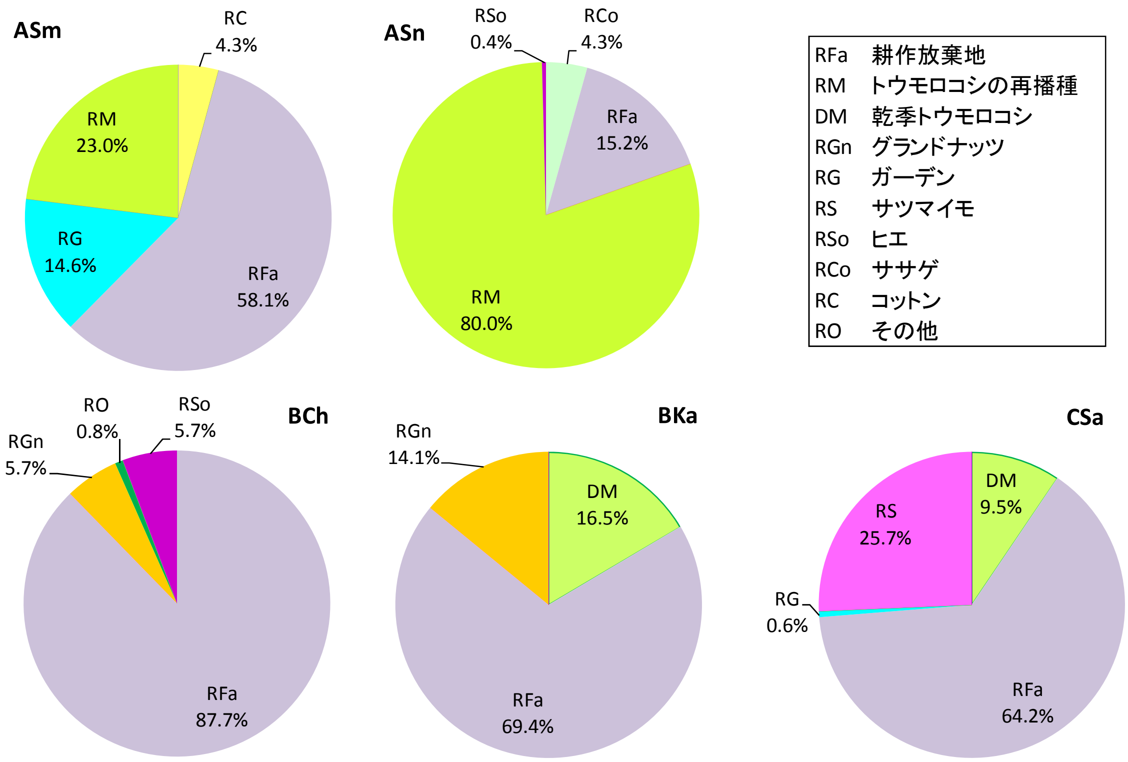

図 3. トウモロコシ畑における多雨被害後の栽培作物面積割合

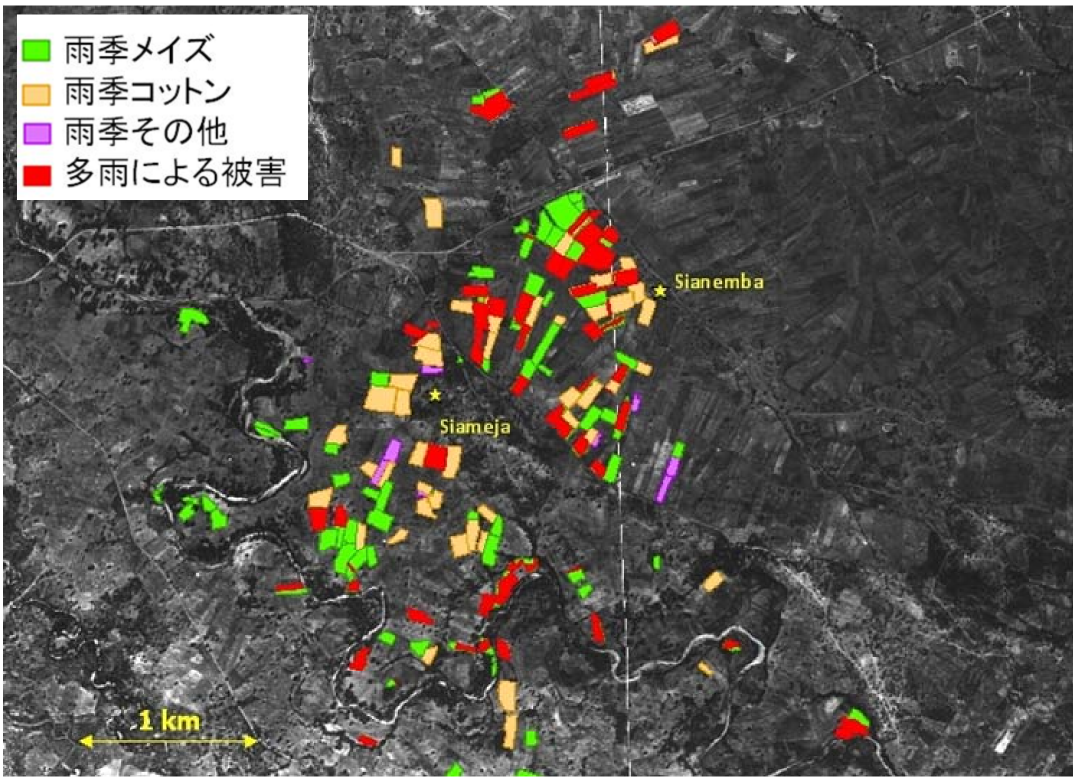

図 4. サイト A（ASm・ASn 村）における雨季畑と多雨による被害畑の分布

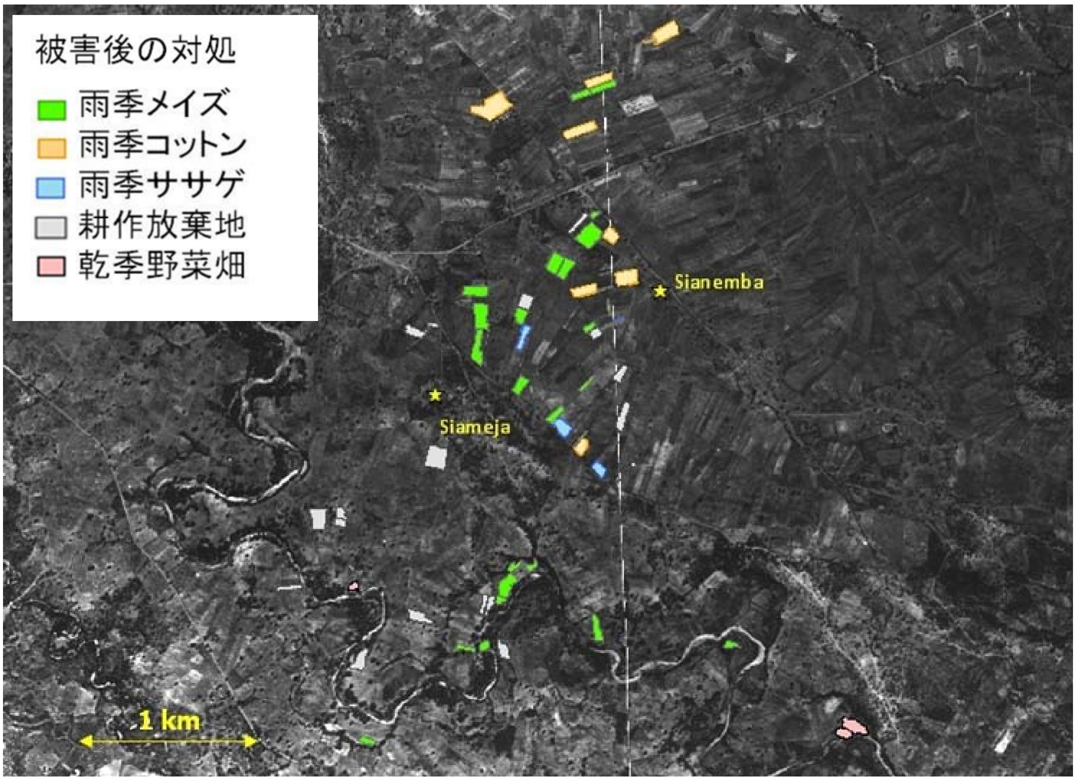

図 5. サイト A（ASm・ASn 村）における多雨被害後の作付状況

表 2.　雨季畑の 8 割以上が多雨の被害にあった世帯における 2007 年度と 2008 年度の現金獲得状況　（各世帯の全現金収入を 100 とした割合%）

income in 2007	animals	maize	cotton	vegetable	gathering	fish	bar	carpenter	piece work	others
Asm11		30.0	20.0	30.0			20.0			
Asm27		50.0			20.0					30.0
Asn8		50.0						20.0		30.0
Asn16		20.0							80.0	
Asn18		5.0	90.0						5.0	
Asn29		50.0	40.0						10.0	
Asn37		50.0							50.0	

income in 2008	animals	maize	cotton	vegetable	gathering	fish	bar	carpenter	piece work	others
Asm11	50.0									50.0
Asm27		25.0							30.0	45.0
Asn8			80.0	20.0						
Asn16									100.0	
Asn18						75.0			25.0	
Asn29	40.0		20.0							40.0
Asn37									100.0	
Asn38	20.0					80.0				

ザンビア・シナゾングウェ地区における NGO の活動と食糧安全保障プログラム

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＜**2009** 年度の調査概要と研究成果の要約＞

2009 年度は、8 月～9 月にザンビアの南部州・シナゾングェ地区において、NGO の食糧安全保障プルグラムについて、おもに World Vision（WV）と Kaluli Development Foundation (KDF)の活動を中心に資料収集と現地調査を行い、取得データを分析した。

① **WV の活動に関する調査**

今年度の WV に関する調査は、リリーフを中心とした'Humanitarian and Emergency Affair (HEA)' オフィスの食糧援助にもとづく活動に注目した。シナゾングウェ地区において、WV HEA は、これまで'Consortium of Southern Africa Food Emergence (C-SAFE)（2006 年 1 月から 9 月まで）と'Consortium for Food Security Agricultural, AIDS Resilience and Marketing (C-FAARM)'（2007 年 9 月から 2010 年 8 月までを予定）というふたつのプログラムの実施を担ってきた。ふたつのプログラムに関する資料を比較すると、C-SAFE が 2005／06 年の干ばつ後の救済活動を中心に地区の広範囲において大規模な食糧援助を実施してきたのに対して、C-FAARM が、より開発に重心をおいたプロジェクトへの参加を前提とした食糧配布（'Food for Asset'）と農民に栽培作物の種子を配布して農業の生産性向上を目指す'Seed Distribution／Seed Monitoring'を柱とし、プログラムの実施拠点も C-SAFE から半減し、規模が縮小していることがわかった。アクセスの問題などから、Chiyabi や Siameja といった遠隔地がプログラムから除外され、道路網の整備された地域に限定した活動になっており、住民へのインタビューからはその実施地域の少なさを問題視する声も聞かれた。

② **KDF の活動に関する調査**

KDF での資料収集と現地調査にもとづき、食糧安全保障に関する活動（たとえばザンビア全土で実施され、KDF が地区での実施主体となっている'Food Security Pack'など）について分析した。また、KDF が地区での実施を担っている政府の食糧援助について、前年度に参与観察した食糧配布の記録と今年度に収集した資料にもとづき、その活動内容や運営の問題点について整理した。KDF のスタッフへのインタビューなどからは、政府による運営資金の支払いが遅延したり、食糧運搬用のトラックの故障などから、たびたび各サテライトへの食糧配布が遅れており、予定された期間内での速やかな配布ができていない実態が明らかになった。

＜今後の調査計画＞

2010 年度は、これまでの調査結果をふまえながら、さらに食糧援助がローカル社会にどのようなインパクトをもたらしているかを現地調査にもとづいてあきらかにする。とくに、食糧援助の配付が村人にどのように受け止められ、どういう対応がなされているのか、それらが農村社会のレジリアンスといかなる関係にあるのか、注目して調査を進めたい。

社会生態システムの空間的レジリアンス
— ザンビア南部州における世帯レベルのリスクと対処戦略 —

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空間的関連性と空間作用は複雑に社会生態システムのレジリアンスに影響を与える。本稿では社会生態システムにおけるレジリアンスの解析に対する空間的視座の有用性を示すための関連文献のレビューを行い、ザンビア南部州での広域家計調査の予備解析からいくつかの事例を示す。ここでは空間レジリアンスという用語を、気候変動に対する小自作農のレジリアンスに対して、空間配置、空間作用そして空間状況がどのように関連するのかを特徴付けるために用いている。さらに、本予備研究が、対象地域である東部州と南部州のより包括的な解析に推移するための基本的な枠組みについても示している。

世帯のレジリアンス測定方法としての児童の成長
― 新しい成長標準値に基づく児童栄養状態の再考 ―

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本論文では児童の健康と栄養状態を社会生態レジリアンスのフレームワークから検討する。「年齢に対して低身長(stunting)」、「身長に対して低体重(wasting)」、「年齢に対して低体重(underweight)」などの指標は、世帯がショックから回復する能力を決定する世帯の可能な資源に密接な関連があるため、栄養指標は世帯のレジリアンスを計測する方法として利用できると議論されている。本稿では、国レベルでのサンプル調査である生活状態モニター調査 (Living Condition Monitoring Survey) を利用し、5 歳以下児童の栄養状態とその傾向を検討する。身体測定指標を WHO の 2006 年 WHO multi-growth center のデータに基づいて計測し、この結果を 1978 年ザンビア全国児童健康調査の児童標準成長曲線に基づくザンビア中央統計局(CSO)の計測結果と比較した。WHO の標準では標準児童の身長が 1978 年ザンビア全国児童健康調査の標準値よりも高いため、「年齢に対して低身長(stunting)」と「身長に対して低体重(wasting)」の割合が高くなることが明らかになった。「年齢に対して低体重(underweight)」の割合は、1978 年ザンビア全国児童健康調査の標準値より WHO 標準値と比較した場合では、標準体重が低いために低かった。ザンビアの就学前児童の栄養状態は、「年齢に対して低身長(stunting)」の割合が非常に高く、「身長に対して低体重(wasting)」の割合が低く、「年齢に対して低体重(underweight)」の割合が中程度であるという特徴を持っている。次第に、栄養不良状態は改善の兆しを示している。しかし、1991 年以来ザンビアの栄養状態の分類は変化していない。WHO の限界値分類で定められた栄養パターンでは、いまだに急性栄養不良の割合が低く、慢性的栄養不良の割合が危機的に高いことが特徴的である。しかし、深刻度が深まるような変化が正反対の方向に起こっている。児童を死に至らしめる急性栄養不良は、標準グループでは自然なレベルに近づいているものの、身体的・知的発達に障害となる慢性的栄養不良は 1991 年の構造調整のスタート時に比べるとさらに深刻になっている。約半数の児童が栄養不良である状況下では、ザンビア児童の栄養確保状況は不安定な位置にある。社会的もしくは生態的環境からの大きなショックが経済を直撃すれば、ザンビアの 5 歳以下児童は、全面的な栄養危機に陥ってしまう瀬戸際にある。

インド・タミルナドゥ州沿岸域の農家世帯における津波の影響*

K.Palanisami[1], 梅津千恵子[2], 久米崇[2] , M.Shantha Sheela[3]
[1]International Water Management Institute (IWMI), Hyderabad, India
[2]総合地球環境学研究所
[3]Tamilnadu Agricultural University, Coimbatore, India

2004 年 12 月 26 日にインド沿岸を津波が襲った。最も被害を受けたのは、タミルナドゥ州、ケララ州、アンドゥラ・プラデシュ州であった。タミルナドゥ州は 4 つの郡に被害が集中した。本研究では、インド・タミルナドゥ州ナガパティナム郡において 2005 年から 2008 年の間に実施した 240 世帯の調査に基づいている。調査の結果、約 77%の農家世帯が津波以前には農業に従事していたが、この割合は津波後には 25-37%に減少していた。非農業セクターでは、津波以前には調査世帯全体の 10%が商店経営などの非農業活動に従事していたが、津波後の非農業活動への従事率は 24-38%へ増加していた。賃労働に従事する割合は津波前の 11%から津波後の 50%へ増加した。稲作の技術効率性は 83%程度であり、さらに 17%の効率の増加が可能である。土壌と水分の分析では、ナガパティナム郡の農業生産環境は津波後に急速に回復したことを示している。稲作はこの地域の主要な農作物であり、純益は 2006 年のヘクタール当り 3695 ルピー から 2007 年のヘクタール当り 6405 ルピーまで変動した。津波の影響を受けなかった地域の純益はヘクタール当り 5600 ルピー からヘクタール当り 8500 ルピー まで変動したことに比べると沿岸域の稲作生産のリスクが高かったことを示している。農家収入を増加させ、農業のリスクを最小化するために作付管理や農作物保険等のプログラムの導入が示唆される。

* この論文はドイツ・ボン市で 2009 年 4 月 26-30 日に開催された IHDP Open Meeting 2009 – 7th International Science Conference on the Human Dimensions of Global Environmental Change の報告論文である。本論文は総合地球環境学研究所とタミルナドゥ農業大学によって 2005 年から 2008 年に実施された共同研究の成果の一部である。

平成21年度 研究計画ワークショップ
（レジリアンスプロジェクト第8回ワークショップ）

日時：　平成 21 年 6 月 6 日（土） 9:30 - 17:00
場所：　総合地球環境学研究所　セミナー室 3・4
〒603-8047　京都市北区上賀茂本山 457 番地 4
Tel.　075-707-2206 (宮嵜)

6 月　6 日（土）　09:30-17:00

9:30-10:00　受付

10:00-10:15　開会の挨拶
レジリアンスプロジェクトの今後の重点課題
梅津　千恵子　（総合地球環境学研究所）

平成 21 年度の研究計画　（司会　梅津）
10:15-10:45　テーマⅠ　環境変動下での人間活動と生態レジリアンス
真常　仁志　（京都大学大学院農学研究科）
10:45-11:15　テーマ II　不確実な環境に対する世帯とコミュニティーの対応
櫻井　武司　（一橋大学経済研究所）
11:15-11:45　テーマ III　脆弱性増大のポリティカル・エコロジーとレジリアンス
島田　周平　（京都大学大学院アジア・アフリカ地域研究研究科）
（代理発表　梅津　千恵子）
11:45-12:15　テーマ IV　社会-生態システムに対する統合解析
吉村　充則　（(財) リモート・センシング技術センター）

12:15-13:45　昼食/コアメンバー会議
（注：昼食は各自ご用意ください。）

個別研究計画発表　（司会　真常）（発表 10 分、質疑　5 分）
13:45-14:00　インドタミルナドゥの津波被害からの回復
久米　崇　（総合地球環境学研究所）
14:00-14:15　テーマⅠ-2　生態レジリアンスと人間活動の相互関係
宮嵜　英寿　（総合地球環境学研究所）
14:15-14:30　カリバ湖周辺におけるグェンベトンガの家畜放牧をめぐる諸問題
岡本　雅博　（総合地球環境学研究所）
山下　恵　（学校法人　近畿測量専門学校）

14:30-14:45　旱ばつに対する世帯生産のレジリアンスと５才以下の栄養状態の決定要因
Thamana Lekprichakul　（総合地球環境学研究所）
（代理発表　梅津　千恵子）

14:45-15:00　プロジェクトのデータと研究の統合に向けて（仮題）
梅津　千恵子　（総合地球環境学研究所）

15:00-15:45　総合討論

15:45-16:00　休憩

16:00-17:00　講演　（司会　吉村）
カルトグラムによる空間情報の視覚化
井上　亮　（東京大学大学院工学系研究科）

17:00　閉会

18:00-20:00　懇親会

講演要旨

「カルトグラムによる空間情報の視覚化」

東京大学大学院　工学系研究科　社会基盤学専攻
井上　亮

カルトグラムとは、空間情報の属性値の大小を、地図上の距離の長短や面積の広狭で表現するよう地理的な地点配置や地域形状を変形した地図で、空間情報の空間的偏在や時間的変遷を印象的に表現できる視覚化手法である。この新しい作成法について説明した後、交通利便性や人口などの空間情報に対する適用例を示す。

レジリアンスプロジェクト第１０回ワークショップ

日時：　平成 21 年 10 月 30 日(金) 09:45-18:00, 31 日 (土) 10:00-16:30
場所：　総合地球環境学研究所　セミナー室 3&4
〒603-8047　京都市北区上賀茂本山 457 番地 4
Tel.　075-707-2209 (担当：久米)　Fax.075-707-2506

10 月 30 日 (金)　09:45-18:00

09:45-09:50　開会の挨拶
阿部　健一　(総合地球環境学研究所)

09:50-10:00　開会の挨拶・年末発表会～最終年度に向けて
梅津　千恵子　(総合地球環境学研究所)

10:00-11:00　テーマⅠ　環境変動下での生態レジリアンスと人間活動　(司会　島田)
真常　仁志　(京都大学農学研究科)

11:00-12:00　テーマⅡ　変動する環境への家計とコミュニティの反応　(司会　吉村)
櫻井　武司　(一橋大学)

12:00-13:00　昼食　(臨時コアメンバー会議、於セミナー室５)

13:00-14:00　テーマⅢ　脆弱性とレジリアンスに関するポリティカル・エコロジー：歴史的・制度的観点から　(司会　真常)
島田　周平　(京都大学 ASAFAS)

14:00-15:00　テーマⅣ　社会生態システムに対する統合解析　(司会　櫻井)
吉村　充則　(RESTEC)

15:00-15:10　休憩

15:10-16:50　討論 (２日目の総合討論に向けた Theme summary＆Discussion)　(司会　梅津)

16:50-17:00　休憩

17:00-18:00　レジリアンス研究会　(司会　久米)
技術協力の現場として見たアフリカの農業・農村
新保　義剛　(農林水産省近畿農政局)

19:00-21:00　懇親会

10 月 31 日（土） 10:00-16:30

10:00-11:00　　社会生態システムの脆弱性とレジリアンス

梅津　千恵子　　（総合地球環境学研究所）

11:00-12:00　　総合討論 I （年末発表会）　（司会　久米）

- レジリアンスの概念について
- 2008 年 2 月 WS 時の概念に関するアンケートの復習

12:00-13:00　　昼食

13:00-15:30　　総合討論 II （年末発表会）　（司会　梅津）

- 年末発表会における発表の重点項目について
- 全体の作業仮説と期待される成果について

15:30-16:30　　最終年度までの全体計画について　（司会　久米）

- FR3-5 におけるプロジェクトの流れ説明
- 国内 WS の開催時期について
- 国際 WS の開催時期について
- 最終成果物（Book Title および Chapter）について

16:30　　閉会

平成 21 年度レジリアンス研究会要旨

第 27 回レジリアンス研究会

日時：2009 年 7 月 8 日（水） 15:00-16:00

場所： 地球研セミナー室 3、4

タイトル： 気候変動が穀物の収量と収量変動及び食料生産最大化のための最適土地作付体系へ及ぼす影響の計量化 ―タミルナドゥ州の異なる農業気候ゾーンにおける計量経済分析

講演者： Prof. C.R. Ranganathan, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India

使用言語： 英語

［要旨］

本研究では、気候変動下での最適土地利用計画のフレームワークを提供する。気候変動が農業生産へ与える影響は多方面にわたる。すべての農業生産活動は非常に気候変動に対して敏感であり、作物収量の変動を伴う。よって、気候変動の影響を平均収量のみではなく、変動について研究することが必要である。定量的な情報は自然資源の賢明な利用と作付体系の最適化のために利用されるべきである。回帰分析を使った過去の研究では、平均生産性にのみ注目し、気候変動にともなう作物生産性の競合による最適作付体系にはあまり関心がなかった。都市化によって農業用地が減少している状況では、この問題はさらに重要度を増している。本研究では、この問題をタミルナドゥ州で生産されている主要作物について検討する。計量経済分析により、平均収量と変動収量、そして異なる作物収量の共分散を推計する。気候変動の影響を反映している推計された平均収量は、多目的線形計画モデルによって最大食料穀物収量、最大米収量、現在の作物生産を維持するための最小農業用地などの目的を達成するために利用される。最後に、本研究では、2020 年のタミルナドゥ州の人口予測と最適食料穀物生産をリンクさせて、一人当たりの可能食料穀物量を決定する。研究の結果、降雨量と温度は生産性と穀物の変動にさまざまな影響を与え、また HADCM3A2a シナリオによる気候変動は、タミルナドゥ州の５区域での作物生産性への影響は小さかった。伝統的な稲作地区では変動の増加と共に生産性も増加した。一方、多くの他の穀物の生産性は減少し、同一的な変化はなかった。土地のみが制約である場合、気候変動による生産性の変化により、作物の最適配分により食料穀物の生産は増加する。これらの結果は政策決定者にとって人口予測下での穀物の供給と需要のギャップを知るために有効である。

第 28 回レジリアンス研究会
日時：2009 年 8 月 3 日（月）　15:00-16:00
場所：　地球研セミナー室 3、4
タイトル：　コモンプール資源システムの制度分析のための空間構造
講演者：　Dr. Tom Evans, Department of Geography, Indiana University, Indiana, USA
使用言語：　英語

［要旨］

　コモンプール資源システム(CPR)の動態は、多様な社会・経済および生物物理的プロセスによって生ずる。それらのシステムの空間構造はしばしば資源管理（森林、水、漁業資源）に影響を及ぼし、それらの資源がどの様に利用されるかを統治しながら制度や規則も発達させてきた。先行研究では、どの様な制度が社会・生態システム(SES)をレジリアントもしくは持続可能にするかを説明するためのフレームワークを扱っていたが、これらのシステムに固有の空間的関連を明確にはしていなかった。本研究の目的は、アクターと資源、そしてその SES 内の関係を、人間と環境の相互作用に固有の空間的関係に焦点を当てて記述するためのオントロジーを開発することである。コンピューターサイエンスではこのオントロジーという用語は概念的フレームワークの実行を意味する。分析のためには、オントロジーは個別のケース・スタディのデータをサイト共通のフォーマルなデータベースとして解釈するために利用される。このオントロジーを使って、どの空間構造が SES のレジリアンスや持続可能性に貢献しているのかを検討する。SES の多くの要素は明示的に空間的特長を持っており、それが部分的にアクターの近辺で資源や土地所有の規模へ影響を与えている。ここで提示するオントロジーは、システム内のアクターと資源に焦点を当て、空間的な特徴とシステムの動態に影響している制度的要因を関係づける。3 つのケース・スタディ（アメリカ中西部の共有林、アメリカ南西部の灌漑ネットワーク、メキシコの漁業システム）から、どの様にこのオントロジーのフレームワークが個別のコモンプール資源システムおよび社会・生態システム一般に応用可能かを提示する。

第 **29** 回レジリアンス研究会
日時：2009 年 10 月 30 日（金）17:00-18:00
場所：地球研講演室
タイトル：　技術協力の現場として見たアフリカの農業・農村
講演者：　新保義剛 氏, 農林水産省近畿農政局土地改良技術事務所次長
使用言語：日本語

[要旨]

サブサハラアフリカの小農の営農形態は、主として天水農業であり、特に南部アフリカにおいて灌漑施設を備えた大規模な商業農園と対照的である。しかし、小農にも多様性を見出すことはできる。サブサハラ地域の主食は主としてトウモロコシと小麦だが、同様にミレット

やソルゴー等の雑穀も重要な食料である。さらに、ウガンダとその周辺では甘くないバナナが主食である。特に陸稲を含む稲は多くの国で重要視されている。日本の技術協力は、主食としてのトウモロコシやミレット等の雑穀の技術的背景は十分ではない。コミュニティーについては、井戸やため池を含む小規模の灌漑が農家グループにより運営されている。しかし、そのグループはモンスーンアジアの灌漑水利組合に比べると組織としての機能性は十分ではない。いくつかの小農をターゲットとする日本の技術協力では、乾季における灌漑を導入し、例えば市場向け園芸作物により農業収入の機会を創出し、農家のやる気を引き出して持続可能な農業の展開を目的とする。もちろん、主食の安定的な収穫確保も生活の安定と健康維持のため、重要であることはいうまでもない。残念ながら、政府が掌握する市場では主食穀物の価格は低い。そのため、主食穀物の収穫増加への意欲と収入機会の創出は両立しない。どのような技術、手段、手法がモンスーンアジアと全く異なるサブサハラアフリカの半乾燥地やサバンナに適当適切か、検討されなければならない。

平成21年度 E-04(梅津FR3)研究活動一覧												2010.2.12
2009	4	5	6	7	8	9	10	11	12	1	2	3
レジリアンス研究会				15:00-16:00	15:00-16:15		16:00-17:00					
				7月8日	8月3日		10月30日					
				(第27回)	(第28回)		(第29回)					
コアメンバー会議	＊4/11		＊6/6		＊8/7		＊10/30		＊12/4		＊2/26	
ワークショップ			研究計画WS 6/6		8月28日		WS 10/30-31					Tsunami WS
			10:00-17:00		2nd Lusaka WS		地球研				16:00-17:30	3/1-3 Singapore
レジリアンス勉強会			第8回WS		(第9回WS)		第10回WS				＊2/26	(第11回WS)
FR3報告書									FR3報告書原稿締切		2月末製本	HP 掲載
予算計画	人間文化研究				(追加予算申請)	追加予算配分			(所要額調)	H22予算計画 1/8		H23予算計画
	総合推進事業申請				8月24日	9月18日			2009/12/17	雇用計画	H22 FR3予算	概算要求
プロ関連行事	4/26-30										ヒアリング2/12	
	IHDP Bonn								12/2-12/4			(FSヒアリング)
	(IS申請 4/7)					(ISヒアリング9/4)			IHDP/ESG			3月5日
	ISヒアリング4/16											
地球研行事				地球研フォーラム			RIHN 国際シンポジウム		プロジェクト		評価委員会	
				7月5日			10月20-22日		研究発表会		2/17-18	
				京都国際会館			地球研		12月9-11日			
フィールド調査日程									コープイン京都			
真常	4/14-5/9				8/25 - 9/4			11/(19) 28-12/24			2/11 - 2/25	
田中						9/17-10/2						
宮嵜	3/16 - 4/27					9/7-10/2					2/1 - 2/15	2/27-3/4 WS
三浦	4/14-5/9											
柴田												
竹中 (M2)	4/14-5/9											
安藤 (M2)	4/14-5/9						9/30 - 10/22				2/11 - 2/25	
宮下 (M2)						8/4 - 10/2	2ヶ月					
櫻井	4/25-5/1 IHDP				8/25 - 8/30		10/4-10/14(28					
菅野							10/4-10/15					
下野	4/1 - 4/11											
山内					8/20 - 8/30							
今 (M1)					8/20 - 9/7							
島田												
半澤					8/18 - 9/3							
児玉谷					(8/18 - 9/3)							
荒木												
岡本	3/5 - 4/5				8/1 - 9/2							
石本	4/25-5/1 IHDP		4/7 - 9/1			5ヶ月			11/15 - 2/15		3ヶ月	2/27-3/4 WS
成澤(D3)	(JSPS)											
伊藤(D2)					8/21 - 9/21							
姜 (M2)												
吉村					8/24 - 9/5		10/17-10/24					
佐伯												
山下					8/24 - 9/5		10/17-10/21					
松村					8/25 - 9/15							
梅津	4/25-5/1 IHDP(JSPS)		6/11-6/22		8/20 - 9/24				12/13-21	(India)		2/27-3/4 WS
Lekprichakul	4/25-5/1 IHDP		6/28-7/5	(Vancouver)	8/12 - 9/12	(Zambia, UK)					2/5 - 3/4	(2/28-3/4 WS)
久米					8/25 - 9/2				(India)	1/17-29	2/27-3/4WS; 3/8-19Sri Lanka	
谷田貝					8/26 - 9/2							
Palanisami	4/24-5/4 IHDP											2/27-3/4 WS
Kajoba	4/25-5/2 IHDP											
Mulenga	4/25-5/2 IHDP											
Ranganathan (招へい)	4/20 - 7/19	地球研										
Evans (招へい)				7/12-8/5 地球研							1/18 - 6/30	地球研

Vulnerability and Resilience of Social-Ecological Systems – FY2009 FR3 Project Report
Project E-04 (FR3)
Project Leader: Chieko Umetsu

March 2010

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社会・生態システムの脆弱性とレジリアンス – 平成２１年度ＦＲ３研究プロジェクト報告
プロジェクトE-04 (FR3)
プロジェクトリーダー　梅津　千恵子

2010年3月

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