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

FY2005 FS Project Report

平成１７年度 FS 研究プロジェクト報告

Project 1-3FS
プロジェクト１－3FS

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Preface

The RIHN feasibility project “Vulnerability and Resilience of Social-Ecological Systems” initially started as an incubation project “Poverty and Resource Management: A Study on Human Adaptation against Environmental Variability” in the fiscal year 2003. Although the title of the project has changed, the concepts and mission of the project remains the same. We want to initiate a project that purpose to enhance human security of rural people in developing countries whose livelihood is critically dependent on environmental resources.

During the fiscal year 2005, project members visited Zambia and discussed with many people including farmers, university professors, researchers, and government officials. The 2004/5 cropping season in Zambia was hit by a severe drought since the major drought in 1991/92 cropping season. About 80-90% of maize production was damaged in Southern and Eastern Provinces. Farmers were trying hard to find all possible measures to survive until the next harvest season with empty food stock. This year we learned that resilience is an important concept not only for food security in developing countries but also in developed countries when the city function is demolished by natural disasters in southern U.S.

Our project has just finished the stage of feasibility study and is trying to move to the next stage. We appreciate 1-3FS members for their endless assistance for drafting a project proposal. We also appreciate kind support by the director, program directors, administration staff and colleagues of RIHN for making this challenging endeavor possible.

February 2006

Chieko Umetsu
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P1－3FS Vulnerability and Resilience of Social-Ecological Systems

Project Leader： Chieko UMETSU Short name： Resilience Project
Keywords： resilience, poverty, social-ecological system, resource management, environmental variability, vulnerability, human security, semi-arid tropics

1. Purpose of Research

1.1 Research Objectives

A. Background and objective

A vicious cycle of poverty and environmental degradation such as forest degradation and desertification is a major cause of global environmental problems. Especially in semi-arid tropics (SAT) including Sub-Saharan Africa and South Asia where a majority of the poor concentrates, poverty and environmental degradation widely prevails. People in this area largely depend on rainfed agricultural production systems and their livelihoods are vulnerable against environmental variability. Environmental resources such as vegetation and soil are also vulnerable against human activities. In order to solve this “global environmental issues”, a key is a quick recovery or a resilience of human society and ecosystems from impacts of environmental variability. Thus in this project we consider society and ecology as one social-ecological system and try to perform empirical analysis for its resilience in semi-arid tropics.

In the past, no serious attention has been paid to the vulnerability and resilience of people whose livelihoods and production systems heavily depend on environmental resources. Especially for farmers and nomads in developing countries who rely on environmental resources, a loss of resilience of social-ecological systems, due to an increase in population and the collapse of rural communities, is of critical importance. The aim of this project is to consider human activity within the context of environmental change in view of social-ecological resilience. Thus, to clarify the effects of local environmental change on social-ecological systems as well as the mechanism through which they recover from shock. Also from various case studies, we will try to identify household and community factors that determine the capacity for resilience, and the role of institutions on resilience. By analyzing factors influencing social-ecological resilience, it is possible to introduce policy interventions for enhancing human security in developing countries. (Figure 1)

The concept of resilience has long been discussed among ecologists after the seminal paper “Resilience and Stability of Ecological Systems” by C. S. Holling (1973). The engineering resilience was defined as recovery time to return to the initial equilibrium before disturbance. This unique equilibrium concept was soon expanded to the concept of ecological resilience that emphasizes capacity to endure disturbance incorporating non-linearity, multiple equilibria and regime shift. Recently, some researchers tried to apply those resilience concepts to complex social-ecological systems (Levin et al. (1998); Levin (1999); Berkes, Fikret & Folke eds. (1998); Berkes, Colding & Folke eds. (2003)).

The above development went in tandem with the emergence of ecological economics that was established during the late 1980s. The important agenda was to link socio-economic research with

ecological research. Ecological economics developed mainly in developed countries has less focus on critical development issues such as poverty and environmental degradation. Also conventional development economics ignored ecological issues that are a base for human economic activities. Thus, there is a need to apply the resilience concept of social-ecological systems in order to solve pressing development issues such as resource degradation and to enhance human security.

In the semi-arid tropics (SAT), the livelihood of the people is vulnerable against environmental variability. The SAT (Figure 2) includes regions such as Sub-Saharan Africa and South Asia where the number as well as the share of the people who live in absolute poverty will remain large for some time to come. People in this area largely depend on vulnerable rainfed agricultural production systems. Thus increasing food security, resilience of livelihood and reducing poverty are acute issues in this area. The G-8 Environment and Development Ministers Meeting held in March 2005 called especially upon the need of research for impacts of climate change on vulnerable livelihoods particularly in sub-Saharan Africa regions. The proposed research aims at considering impacts of environmental variability and increasing resilience of people, which is the pressing global environmental issues for international community.

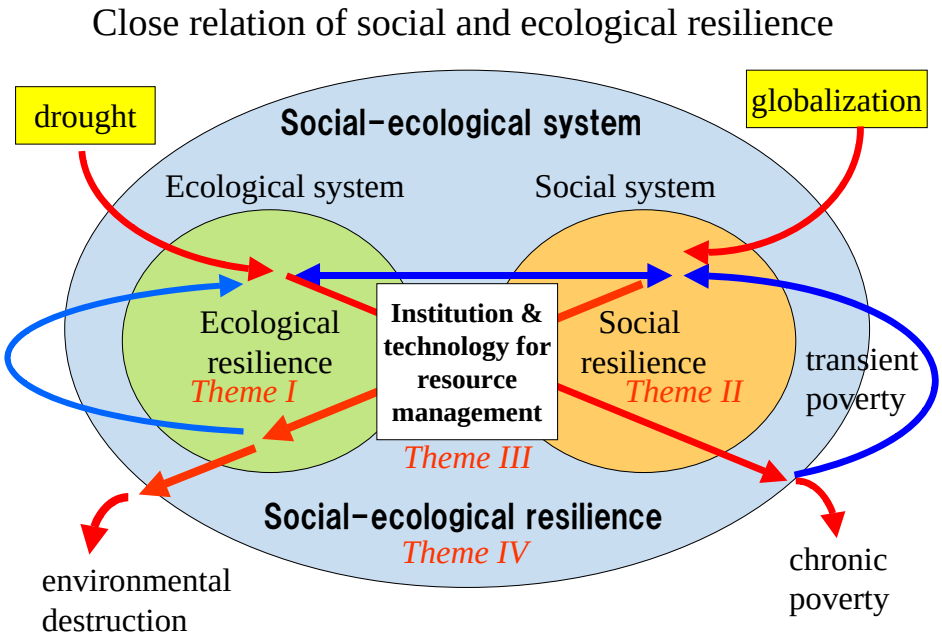


Figure 1. Resilience of Social-Ecological System and Four Themes

B. Objectives of Research

The objective of the research is as follows:

1. We consider impacts of environmental variability through vulnerability and resilience of human activities in semi-arid tropics.
2. We study factors affecting social-ecological systems and the recovery from impacts and shocks.
3. We analyze factors that form the ability of household and community to recover and the role of institution for resilience.
4. Thus we identify the factors affecting resilience of social-ecological systems and the ways to

enhance resilience of rural people in semi-arid tropics against environmental variability.

C. Goal of the Project

We consider environmental degradation caused by “vulnerability” of social-ecological systems as “global environmental issues” and the ways to enhance “resilience” as a primary goal of solving “global environmental issues.” During the research project, data collection, observation and analysis will be conducted to find out some key indicators to resilience. By using those indices, our goal is to provide some options of the ecosystems and resources management at the end of the project.

1.2 Research Organization, Contents and Methodologies

A. Research organization

In order to achieve our objectives, we focus on four themes. Each four themes interlink each other and thus provide comprehensive assessment of resilience of social-ecological systems. Under the supervision of theme leader, respective researchers will participate in sub-programs. Not as ordinary discipline based research groups, we organized theme based research organization. Most researchers involve more than one sub-program, thus making it possible to realize flexible research organization.

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.

First two themes consider site specific or village level analysis and those studies are extended to temporal as well as spatial analysis in the third and forth themes for larger scales. We invited appropriate experts in the respective fields such as agronomy and soil science, agricultural and development economics, anthropology, geography, climatology, and remote sensing. The time scale of the analysis is from 1960s to the present when the changes in social and natural environment have been accelerated. (Figure 4)

Collaborating institutions are as follows:

Zambia

Institute of Economic and Social Research, University of Zambia

Central Statistical Office, Government of Zambia

Mt. Makulu Central Research Station, Ministry of Agriculture and Cooperatives

Meteorological Department, Ministry of Transport and Telecommunications

Survey Department, Ministry of Land Resources

Food Security Research Project, MSU/USAID

India

Water Technology Centre, Tamilnadu Agricultural University, Coimbatore, India

Burkina Faso

University of Ouagadougou, Burkina Faso

B. Research areas

The study areas of the project are the countries in semi-arid tropics (SAT). SAT is characterized by

Figure 2. Regions of Semi-Arid Tropics and Research Areas

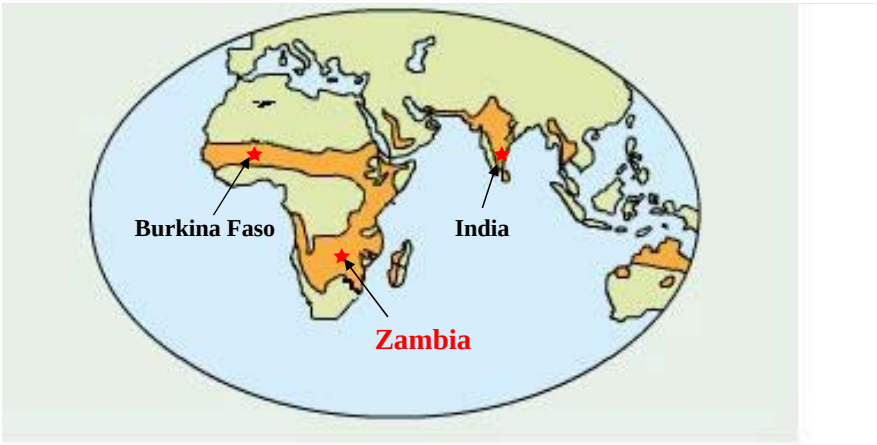


Figure 3. Agro-Ecological Zones in Zambia

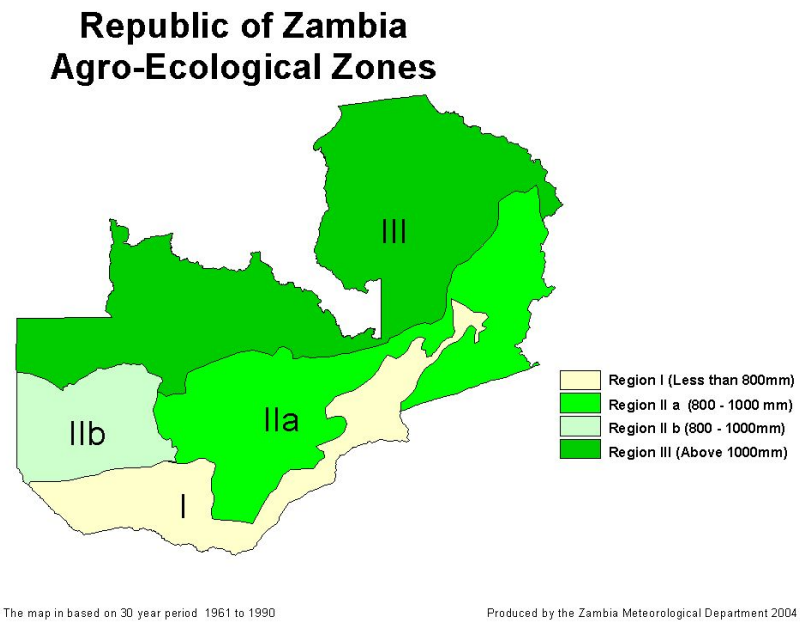
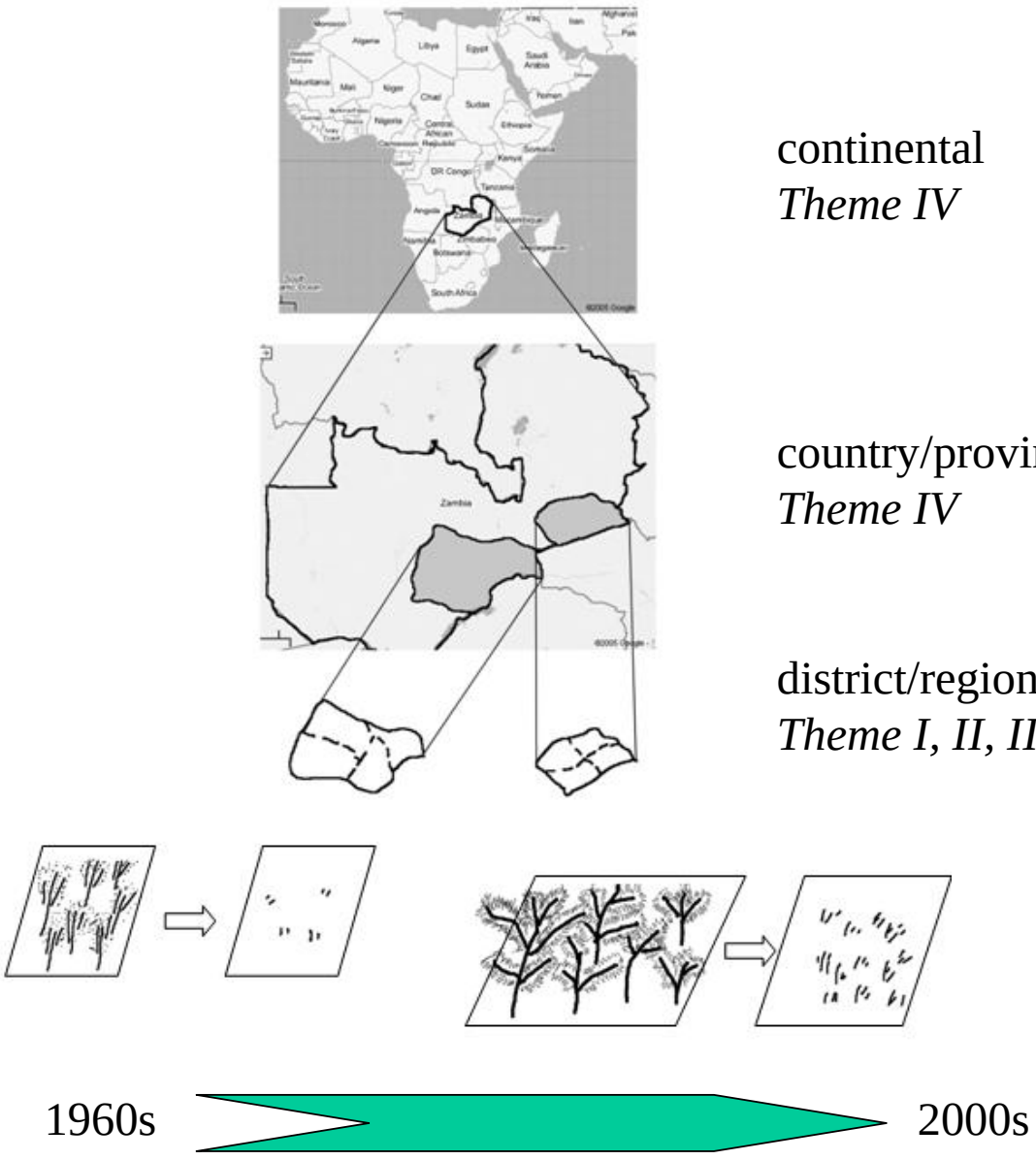


Figure 4. Scale of Analysis



unpredictable weather, long dry seasons, inconsistent rainfall and soils with poor nutrients (Barghouti, 1999). This area is a home of one-sixth of the world's population, a half of them live in absolute poverty with less than one US dollar a day. The large population in SAT live in rainfed agricultural areas and their marginal livelihood is critically depends on fragile and poorly endowed natural resources. The target research areas in SAT are Southern Africa region (Zambia, Zimbabwe), West Africa region (Burkina Faso, Niger), and South Asia (India). Particular emphasis will be placed on the rural agricultural areas in Zambia where intensive field survey will be conducted. In Zambia, drought prone Eastern and Centeral Provinces are our target research areas. Those areas are in agroecological zone of I and IIa where annual rainfall is less than 800 mm and between 800 mm and 1,000 mm respectively. (Figure 2; Figure 3)

C. Research contents and methodologies

This project tries to provide quantitative and qualitative assessment of resilience of social-ecological systems. Resilience of social-ecological systems largely consists of i) the capacity of natural and social systems to absorb shocks as well as ii) the coping mechanisms when the shock occurs. Those capacity and coping mechanisms may be affected by external socio-economic environment such as institutional changes. We set four themes as follows: The theme first tries to consider ecological resilience through human activities. The second theme analyzes resilience of household and community through ecological conditions. The third theme considers resilience through historical and institutional perspectives. The fourth theme tries to integrate previous three themes for the evaluation of social-ecological resilience in larger scale.

Theme I: Ecological Resilience and Human Activities under Variable Environment (Theme Leader: Hitoshi SHINJO)

Ecological resilience can be defined as the potential of ecosystems to provide people with services in a sustainable manner. In this sense, it is commonly believed that human activities, such as cropping, grazing and tree cutting for fuel, may adversely affect ecological resilience, leading to land degradation. Nevertheless, the non-linearity and variability in the relationship between the human activities and the ecosystems often makes it difficult to find the clear evidence of the cause-effect relationship. In the semi-arid tropics (SAT), particularly, the inter-annual fluctuation of rainfall sometimes mask the change of ecological resilience caused by the human activities. The sub-theme I-1 will deal with the impact of human activities on the ecological resilience with the intensive field experiment, where the spatial and temporal variability of the possible indicators of ecological resilience will be measured. Besides the impact of human activities, we also clarify the interrelations between the ecological resilience and the human activities in the sub-theme I-2, since people in SAT depending heavily upon the ecological resources seem to recognize and cope with the variability of the ecological resilience for stabilizing their livelihood.

By compiling the sub-themes I-1 and I-2, we identify the status of the ecological resilience in the lands of the study areas, how people's welfare depends on the ecological resources and how the ecological resilience changes under the impact of human activities, to develop some sound options of the ecosystems and resources management in SAT.

I-1 Components, capacity and succession of ecological resilience under different human intervention and variable environment (Shinjo, Tanaka, Miura, Shibata, and Saeki)

Although we can define the ecological resilience as above, we have not yet understood how we can parameterize the ecological resilience. Since the past ecological studies strongly suggest the importance of variability and redundancy of ecosystems for their resilience, we will monitor spatial and temporal variability of land characteristics, and try to evaluate the components, capacity and succession of ecological resilience during the process of conversion from stable fallow woodland to agricultural land in Petauke, Eastern Province of Zambia. For this purpose, we will open a parcel of relatively stable Miombo woodland for cropping every year or, in some parcels, returning to fallow during 5 years, to prepare the lands under different levels of human intervention. With the experimental design, the effects of fluctuating climatic factors and the impacts of human activities can be detected independently, unlike the past studies on slash-and-burn farming that have attributed all the temporal changes to human activities. In this field experiment, spatial and temporal variability of the soil properties, the nutrient cycling, the components of plant communities and the micro-climatic variables are determined. Among the variables, we try to identify quantitative indicators that explain the ecological resilience of the study site. In the later period, land capability with different degrees of human intervention and land use history under the same climatic condition of the particular year can be compared in order to evaluate the decrease or regime-shift of ecological resilience of the study site.

I-2 Interrelations between ecological resilience and human activities and its succession under different agro-ecosystems (Tanaka, Shinjo, Miura, Shibata, Miyazaki and Saeki)

It is commonly observed in SAT that one household cultivates the several parcels of the land different from each other in terms of ecological resilience. This way of land management is thought to be “risk management” which helps people cope with the environmental variability. In this sub-theme, how people cope with the variable ecological resilience is revealed by monitoring and comparison of some land characteristics, which are related to ecological resilience, under different landscape, e.g. valley, slope and plane land, the types and histories of land use, and succession stages of agro-ecology. For the detailed study, we identify the conditions and properties of every cultivated and fallow plots of each household, e.g. the areas and boundaries by GPS apparatus, some selected soil properties such as organic matter content and effective soil depth, and the composition of grass and shrub species. In collaboration with the Themes II and III, these results comprehensively explain and define the integrated concept of socio-ecological resilience. Target areas are cultivated and fallow lands of the sample households in Petauke, Eastern Province, and Sinazongwe, Southern Province of Zambia.

Theme II: Household and Community Responses to Variable Environment (Theme Leader: Takeshi SAKURAI)

Rural households in the semi-arid tropics have developed various kinds of risk-management and risk coping mechanisms to respond unpredictable rainfall, particularly in sub-Saharan Africa where credit and insurance markets are generally imperfect. Some of the mechanisms such as borrowing and gift-receiving depend on relatives and friends in the same or neighboring villages, and hence in the case of severe drought they will not work well because most of the farmers are simultaneously affected. On the other hand, there are other kind mechanisms that rely on natural resources for

example food gathering in the bush and utilization of wet valley bottoms. As such, which mechanisms a household utilizes and how much extent the mechanisms are effective will be determined by the assets that the household has, natural resources that are available for the household, the severity of the drought, the community characteristics, and so on. At the same time, the natural resource endowments should be affected by rural households' behaviors against droughts. For example, if many households rush for wild foods in the bush, the resources will be exhausted and will not serve as a safety net in the next drought. In other words, the resilience of households and that of ecosystem are dynamically inter-reliant. And because of this inter-reliance, households in the semi-arid tropics are often trapped in the vicious cycle of poverty and environment degradation. This is the fundamental issue that this research project addresses, and we, the project members, consider that the analysis of socio-ecological resilience will show us the way-out from the trap.

In order to serve for the integrated analysis of socio-ecological systems, the theme II investigates rural households' strategies against the erratic rainfall in four interrelated sub-themes. Theme II-1 is to measure the risky event objectively, that is, rainfall. Theme II-2 concerns with the endowments of resources available to households including physical, natural, human, financial, and social capitals. Theme II-3 is devoted to the analyses of households' behaviors: risk-management before the rain, adjustment during the rainy season, and risk-coping after harvest. And finally in theme II-4, households' resilience in risky environment is evaluated in terms of income-smoothing, consumption-smoothing, and nutritious status. The details of each sub-theme are as follows.

II-1 Measurement of spatial and temporal distribution of plot-level rainfalls (Saeki, Kanno)

It is well known that in the semi-arid tropics rainfall variability is very large even within a village. Moreover, crops are severely affected if there is no rain in the critical stage even annual rainfall level is high enough. That is, temporal distribution of rainfall also does matter. Nevertheless, most drought studies use annual rainfall observed at regional weather station, simply because spatial and temporal rainfall distribution at plot-level cannot be observed. This is the most significant weakness of existing drought studies. Hence, in this sub-theme, daily rainfall on every sample household's plot will be recorded by utilizing small rain gauges, and the characteristics of spatial and temporal rainfall distribution within a small area will be analyzed. For rural households, rainfall is the most precious natural resource for their subsistence, but the resource availability is not predictable unlike other natural resources such as soil and vegetation. In other words, rainfall is considered to be a risky asset.

II-2 Investigation of households' capital endowments (Sakurai, Shinjo, vegetation specialist)

How a household manages drought risk and copes with drought is a function of not only the magnitude of drought shock but also the resources available to the household. Therefore, in theme II-2, households' capital endowments other than rainfall will be investigated. They include natural capital (agricultural land, fallow land, forest land, livestock, and so on), physical capital (agricultural equipments, houses, and so on), human capital (composition of household members, their education level, their skills, their health status, and so on), financial capital (potential money-lenders, potential gift-givers, saving, and so on), and social capital (membership, network, trust, and so on). Note that some of them are risky asset: for example, livestock holdings and human capital are subject to diseases and death. How risky they are is an empirical question to be answered in this research project like

rainfall variability. On the other hand, some assets such as soil and vegetation will not change a lot during the short research period although we consider that their depletion is a serious problem in the semi-arid tropics. Data will be collected by physical measurement or interview. The advantage of multidisciplinary approach of this research project is the involvement of natural scientists in the physical measurement such as soil and vegetation condition of agricultural land, and health status of household members.

II-3 Analyses of households' behavior against rainfall variability (Sakurai and agronomist)

Given the various kinds of capital endowments measured in sub-themes 1 and 2, the question is how households in the semi-arid tropics behave under the risky environment. Household behavior can be classified into three categories: risk management before the rain, adjustment during the rain season, and risk coping after the harvest. In sub-theme II-3, household behaviors will be recorded by weekly interview, which will enable us to investigate the effect of rainfall and capital endowments on how households' decisions about agricultural input, off-farm labor supply, livestock and other asset transaction, borrowing/lending, gift-giving/receiving, expenditure, consumption, and so on. Since daily rainfall is recorded in sub-theme 1, sub-theme 3 will reveal how households adjust their subsistence strategies during the rain season, which has been rarely studied due to data limitation. As for the risk management before the rain, crop and plot diversification is one of the important strategies to mitigate rainfall risk. With this regard, crop choice (e.g., drought-tolerant crops or drought-susceptible crops), varietal choice (e.g., early maturing or late maturing), and technology choice (e.g., with tillage or without tillage) will be analyzed from the agronomic view point.

II-4 Evaluation of households' resilience (Sakurai and anthoropometrics expert)

Finally, in sub-theme II-4 the performance of households' risk management and coping behaviors will be evaluated from the viewpoint of resilience. Ignoring ecological aspect for a moment, in this sub-theme income smoothing and consumption smoothing will be used as criteria of households' resilience. They will be evaluated not only within a year (i.e. seasonal variation) but also over years (i.e. yearly variation due to the rainfall) using the data collected by the weekly household interview over years during the project period. However, a criticism about this method is that household income and consumption (or expenditure plus self-consumption) cannot be physically measured even in weekly interviews. Hence, in order to have an objective indicator, we will conduct anthropometrics: namely the measurement of body weight and height. They will be used as a criterion of households' resilience.

Theme III: Political-Ecology of Vulnerability and Resilience: Historical and Institutional Perspective (Theme Leader: Shuhei SHIMADA)

This theme tries to focus on the institutional aspects of social resilience in the area of semi-arid tropics. Social resilience undergoes change along with social, political and economic change and also with ecological change. It is important to understand both in the context of local history and physical settings.

Social resilience has close relation to social vulnerability. They are the both sides of a coin. As the study of social vulnerability has far developed than that of resilience, it is helpful to take

advantage of the results of the vulnerability study. It is said that there are two sides of vulnerability; external side and internal side. The former has relation to risks, shocks and stresses that are caused by uncertain rainfall, price fluctuations, political instability, and other changes in access to markets. The latter has relation to defenselessness of society such as a lack of social security system. And the social resilience has to do with something socially embedded systems and functions that mitigate or alleviate the increased vulnerability.

The semi-arid tropics (SAT) is an area where the external side of risk is high and people's vulnerability is also high. People in the SAT, however, are not despair of their ecological environment. They endeavor to reduce risk, increase adaptability, and seek a degree of autonomy, by several ways. Lots of means are taken to avoid or mitigate the external risks and shocks, and also there are many strategies both deliberate and automatic to get rid of the hardship. Social institutions play an indispensable role to support these endeavor.

Theme III tries to make clear: i) why society at SAT is prone to increase vulnerability?; ii) what is the process of increasing social vulnerability?; iii) what kind of strategies are taken and what sort of social devises including institution are functioning to alleviate the vulnerability?

Each society has different historical background and location. We will pay much attention to the regional specificity not so as to identify the variety of society but to clarify and extract the general factors. We hope that we can find out the portfolios that worked for social resilience to avoid risks and to cope with difficulties. Components of theme III are as follows. The above mentioned focus points will be studied in the course of pursuing these sub-themes.

III-1 Change of economic policy and its impact on agricultural production and land use (Kodamaya, Hanzawa, Shimada, Umetsu)

Impacts of economic change on cultivation system, land tenure, food marketing and consumption will be studied. This is to understand the economic background of change in land use in the study area. The Governmental reports, both national and local level and other publications on agricultural development program will be collected and analyzed in this sub-theme. The increase of cassava production and cash crops, such as cotton and sun flower, and decrease of sorghum and millet production will be studied along with the influence of agricultural policies.

III-2 Socio-political change and its relationship to the change of land use (Shimada, Araki, Kajoba)

Change in customs and social institutions that have relation to agricultural production will be studied in this sub-theme. Traditional land tenure system, mutual help system both intra- and inter-kin groups, community-based resource management, and self-help institutions will be studied. Institutions are viewed here as dynamic terms and as the products of social and political practices. The change of institution inevitably cause change in the position of stake holders, which then have repercussion to the former again. This is why long-term field study based on participatory observation will be important for this study.

III-3 Vulnerability and social resilience of household and community (Shimada, Umetsu, Araki)

Historical narrative on drought, heavy rain, poor harvest, marketing failure of products will be

collected. And discourses about the reasons of poor harvest and failure in marketing will be analyzed in the context of socio-economic change. The experience of reduced consumption, off-farm works, asset disposal, exploit of community help, gleaning, collection of fuel, gathering wild foods among others will be interviewed in different types of household such as cattle rich household or women headed household. For the collection of data, we will conduct intensive household level interview in some of study areas. The functions of social institutions and cultural background will also be studied that have played an important role for the mitigation or even eradication of vulnerability. In this sub-theme, some of non-agricultural factors, such as the impact of HIV/AIDS, migration, and activities of NGO's will also be studied.

Theme IV: Integrated Analysis of Social-Ecological Systems (Theme Leader: Mitsunori YOSHIMURA)

The primary goal of this research theme is to clarify the relationship between ecological vulnerability, resilience and human activities through investigations of changes in ecological system and multi-level social system. For this purpose, we select drought disaster and early warning system for food security as a case study. The drought is known as one of the serious natural disaster for local people. Also the drought causes luck of food and it is the word that expresses poverty of African countries typically. Therefore early warning system (EWS) for food security has been discussed from the 1980's when severe famines hit the continent. Here we try to clarify the mechanism of drought occurrence and do its disaster monitoring with three different spatial scales such as global/continental, country and district level. Furthermore the vulnerability and resilience of the ecological system will be summarized by integrating the results of this analysis with historical, socio-economic background in order to understand the impacts on rural communities by country level actions of early warning system for drought disaster.

IV-1 Global monitoring on environmental change (Saeki,Yoshimura)

In order to know the characteristics of African semi-arid tropics (SAT) region, its climate and geopolitical conditions will be clarified. Through the climate research, the occurrence mechanism of natural disaster such as drought will be clarified by the climate change monitoring with global/continental level. Trough the geopolitical research, human impacts of natural disaster will be investigated and its rural communities influence will be clarified by vital statistics with country scale.

IV-2 Land use change and its impact on ecological system (Yoshimura, Yamashita, Cultural Anthropologist)

In order to know ecological system influences by environmental change (drought disaster), forest degradation and vegetation change will be investigated. For these investigations, land cover and use change analysis will be conducted using multi-temporal aerial photographs and satellite imageries. Through these analyses, human influences of environmental change will be considered and compared its results and historical and social background.

IV-3 The early warning systems and food security (Umetsu, Yoshimura, Cultural Anthropologist)

In order to understand Food security as an emergent issue for Sub-Saharan Africa, The role of the

United Nations (UN), World Food Programme (WFP) for the constructing the early warning system (EWS) will be investigated. The practical problems and what kinds of EWS functions are useful for rural community will be discussed through field level investigations and what kinds of influence on the resilience of rural communities will be clarified by the actions of EWS.

IV-4 District level analysis of drought responses and resilience index (Umetsu, Saeki, Sakurai, Shimada, Shinjo, Tanaka, Yoshimura)

1) District level statistical data on socio-economic indicators, agricultural production and grain prices are collected from the Central Statistical Office and the Department of Agriculture; 2) Crop Forecast Survey and Post Harvest Survey of Central Statistical Office (CSO) are combined with our own reanalysis planned in year 2006; 3) District level data will be analyzed with socio-economic and institutional factors as well as agro-ecological factors to provide mapping of resilience index; 4) The statistical information would be supplemented by the field interview survey of farm households. Socio-economics indicators are overlaid with agro-ecological information such as rainfall and soil conditions.

2. Outcome up to now

2.1 Research Activities during the Feasibility Study

A. Research organization

- We set four themes as mentioned before and invited appropriate researchers to participate in the project. Their fields include agronomy and soil science, development economics, resource economics, anthropology, environmental geography, climatology, remote-sensing specialist.
- We identified potential collaborating institutions and researchers in Zambia, India and Burkina Faso.
- To prepare for the field research in Zambia, research permits of core members during 2006-2011 have been approved in December 2005 by the Government of Zambia through the assistance of the Institute of Economic and Social Research, University of Zambia. The affiliation procedure of core project members with ISER/UNZA has been completed.

B. Methodologies

During the FY2005, we conducted literature review, field observation and preliminary interview for farmers, we identified some research targets that should be included in our resilience study. Details are mentioned in the previous section.

C. Results of preliminary field research

- The 2004/5 cropping season in Zambia was hit by severe drought since 1991/2 cropping season. Especially in Eastern and Southern Provinces, crop failure of maize ranged between 85-90 percent.
- Recently, drought resistant cotton production is increasing in Eastern and Southern Provinces. The increasing cotton production needs to be examined carefully in the context of food security.
- During the field trip to Zambia in August 2005, we conducted a field observation for the potential field sites in Eastern and Southern Provinces of Zambia. We obtained a partial weather data from the Meteorological Department, Ministry of Communications and Transport. Also we obtained information on geographical data from the Department of Survey, Ministry of Land Resources.

• During the field trip to Zambia in November 2005, we obtained the data set of Crop Forecast Survey for 8000 farm households in the 2004/5-drought year from the Central Statistical Office. We plan to obtain additional data sets for Post Harvest Survey in 2004 and 2005.

• We had a discussion on project collaboration with researchers and the staff of the following institutions.

The Institute of Economic and Social Research, University of Zambia (UNZA); Faculty of Agriculture, UNZA; Mt. Makulu Central Research Station, Ministry of Agriculture and Cooperatives; Central Statistical Office; Survey Department, Ministry of Land Resources; Meteorological Department, Ministry of Transport and Telecommunications; Food Security Research Project, Michigan State University and USAID.

D. The 6th Open Meeting of IHDP at Bonn

• We organized a session (Adaptive Management and Resilience: Local Responses to Environmental Stress and Risks) at the 6th Open Meeting of the Human Dimensions of Global Environmental Change Research Community, 9-13 October 2005 held at the University of Bonn.

E. Meetings held during FS in FY2005

- April 28: 7th Resilience seminar

Title: Rural development scheme that aims at coexistence of economic activity and environmental conservation: The case of Tanzania; Speaker: Ueru Tanaka, Graduate School of Global Environmental Studies, Kyoto University

- June 10: 8th Resilience seminar

Title: The introduction of recent studies on resilience of lake ecosystems; Speaker: Shigeo Yachi, RIHN

- July 21: 9th Resilience seminar

Title: Social transformation and change in land use in East Zambia: the case of new farmland opening by Chewa farmers; Speaker: Ryuta Yoshikawa, Graduate School of Asian and African Area Studies, Kyoto University

Title: Response of agricultural society to variation of international coffee price: economic liberalization in 1990s and the “coffee crisis” in Ethiopia; Speaker: Keiichiro Matsumura, Graduate School of Human and Environmental Studies, Kyoto University

- October 21: 10th Resilience seminar

Title: Reconstructing the concept of “sustainable development” with focus on ecological resilience
Speaker: Satoshi Kojima, Institute for Global Environmental Strategies

- November 25: 11th Resilience seminar

Title: Meteorological data measurement in Mali, West Africa: 2001-1004; Speaker: Hiromitsu Kanno, National Agricultural Research Center for Tohoku Region

Title: How do farmers cope with plot-specific rainfall variability? : The empirical study in Mali, West Africa; Speaker: Takeshi Sakurai, Policy Research Institute, Ministry of Agriculture, Forestry and Fisheries

• December 9: FS member meeting

2.2 Problems and Solutions for Research

A. Problem and solutions during IS/FS study

Although theoretical study is ahead of empirical study in resilience research, few empirical researches have been done that applies resilience to practical development issues. Therefore, it is required to apply this concept to regional problems. We set themes I, II, III that study closely with local communities and then extend further to theme IV with wider geographical scope.

B. Changes made from the initial plan

During the incubation and feasibility study, we initially considered only Zambia and South India. However, in PR we will expand the research area to semi-arid tropics (SAT). Thus it may be possible to have comparative analysis of resilience based on differences of population pressure and land endowment.

3. Research Activities from FY2006 to FY2011

3.1 Time Schedule

	H17 FS	H18 PR	H19 FR1	H20 FR2	H21 FR3	H22 FR4	H23 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	xx	xx	xx	xx	x
Burkina Faso			x	xx	xx	xx	x
International Workshop		x		x			x
Project Report	FS Report	PR Report	Annual Report	Interium Report	Annual Report	Annual Report	Final Report

PR (FY2006)

I: Preparation of the monitoring plots in the Miombo fallow woodland in Petauke site; Pre-treatment for clearing the Miombo fallow woodland (e.g. bark pearing); Preliminary survey on soil, topography and vegetation in Petauke, Eastern Province, and Sinazongwe, Southern Province of Zambia; Selection of the sample households in Petauke and Sinazongwe.

II: Study site will be determined (four villages from Petauke district, Eastern province and another four villages from Sinazongwe district, Southern province in Zambia). They will be selected considering representativeness of each district, variation among them in terms of distance from the district capital as well as rainfall level. Then, census will be conducted in each village, based on which village household will be stratified and sample household will be drawn from each strata.

III: Collect necessary publications and statistical data available to serve for the study III-1. Select three villages or more from the Central, Southern, and Eastern Provinces of Zambia for the study of III-2 and III-3.

IV: Data source retrieval and data collection and data base construction; drought and its related information gathering at international organizations; design of metrological stations

FR1 (FY2007)

I: Setting of weather and soil monitoring apparatus in the Petauke site; Opening of the Miombo fallow woodland (Y1 plot) for cultivation and recording of the entire processes; Field survey and sampling of soil and vegetation in the Petauke plots and laboratory analyses; GPS survey of the plot boundaries of the sample households, hearing and observation of land use at each plot in Petauke and Sinazongwe; Hearing and observation of conventional farming systems and land use types.

II: Rainfall gauges will be installed before rain starts in October. Weekly household interview will also start before the rain. Soil sampling and vegetation study will be conducted during the rain season. Anthropometrics will be carried out at least twice in a year: during the rain season and after the harvest. The data will be shared among sub-themes II-1, 2, 3, and 4.

III: Intensive field study by participatory method will be started to collect household level information about family structure and agricultural production system. This is the base-line study for the sub-theme of III-2 and III-3.

IV: Data analysis for constructed data base in PR: 1) Drought period and area identification using metrological data; 2) Drought disaster monitoring using satellite data; 3) Comparison of district level population data; Set up metrological stations in the fields; Analysis that relates drought and Population statistics; selection of comparative country and regions for Zambia.

FR2 (FY2008)

I: Continuation of the weather and soil monitoring in the Patauke site; Opening of the Miombo fallow woodland (Y2 plot) for cultivation, cultivation in Y1 and Y2 plots, survey of soil and vegetation, measurement of crop yield, sampling and laboratory analyses; Completion of GPS survey, additional GPS survey for newly converted plots, continuation of land use monitoring in Petauke and Sinazongwe; Hearing and observation of minor husbandries (e.g. seasonal labor migration, livestock keeping, gathering and fishing); Preparation and commencement of the comparative field research in Semi-arid India）

II: The same as FR1.

III: Intensive study for III-2 and III-3 will be continued. Records and narratives about misery and difficulties that caused social vulnerability will be collected.

IV: Drought disaster monitoring at Petauke and Shinazongue area; Investigation of EWS and case study for ’90 drought disaster.

FR3 (FY2009)

I: Continuation of the weather and soil monitoring in the Patauke site; Opening of the Miombo fallow woodland (Y3 plot) for cultivation, cultivation in Y1, Y2 and Y3 plots, survey of soil and vegetation, measurement of crop yield, sampling and laboratory analyses; Additional GPS survey for newly converted plots, continuation of land use monitoring, survey of soil and vegetation, measurement of crop yield in Petauke and Sinazongwe; Preparation and commencement of the comparative field research in Semi-arid West Africa）

II: The same as FR1.

III: Intensive study will be continued. The focus of interview will be concentrated on the process of increase of social vulnerability and the processes of alleviation of it.

IV: Seasonal and dairy change analysis of observed metrological Ddta; Agricultural land use and settlement change analysis by aerial photographs; Interviews at villages in Petauke and Shiazoungue; Interviews at villages of PR2 case study area.

FR4 (FY2010)

I: Continuation of the weather and soil monitoring in the Patauke site; Opening of the Miombo fallow woodland (Y4 plot) for cultivation, cultivation in Y1, Y2 Y3 and Y4 plots, survey of soil and vegetation, measurement of crop yield, sampling and laboratory analyses; Additional GPS survey for newly converted plots, continuation of land use monitoring, survey of vegetation, measurement of crop yield in Petauke and Sinazongwe.

II: The same as FR1.

III: Intensive study will be continued. The study of III-3 will be started to analyze the functions of social institution that has played for the vulnerability and resilience of society.

IV: Model development that relates drought disaster and statistics of population based on Zambia research results; Validation of Zambia model at case study area.

FR5 (FY2011)

I: Continuation of the weather and soil monitoring in the Patauke site; Opening of the Miombo fallow woodland (Y5 plot) for cultivation, cultivation in Y1, Y2 Y3, Y4 and Y5 plots, survey of soil and vegetation, measurement of crop yield, sampling and laboratory analyses; Geo-statistical analyses on spatial and temporal variation of soil and vegetation; Additional GPS survey for newly converted plots, continuation of land use monitoring, survey of vegetation, measurement of crop yield in Petauke and Sinazongwe; Analyses on the components and indicators of ecological resilience, inter-relations between ecological resilience and the impact of human activities; Comparative analysis of the ecological resilience in SAT (Southern Africa, West Africa and India) to seek some sound options of the ecosystems and resources management systems.

II: Analyses of the four-year data collected from FR1 to FR4.

III: It is aimed to find out the portfolios that worked for social resilience to avoid risks, to cope with difficulties, and recover from the misery.

IV: Integrated analysis of ecological system and social system

3.2 Outcome Expected until Evaluation Committee Meeting

A. Until FY2005 Evaluation Committee Meeting

- FS project report is under preparation.
- We are trying to contact Central Statistical Office to arrange the supplementary household survey for the same sample households interviewed for Post Harvest Survey in the Eastern and Southern Provinces during the summer of 2006.
- We continue searching researchers to strengthen our project team.

C. Until FY2007 Evaluation Committee Meeting

I-1. Components and some indicators of ecological resilience are revealed

II-1. Quantitative measurement of spatial and temporal distribution of rainfall and its impact on

household behaviors.
III-1. Complex processes of increasing and mitigating vulnerability will be analyzed in connection with local specificity.
IV-1. The occurrence mechanism of natural disaster, human impacts of natural disaster and its rural communities influence will be clarified

Until the FY2011 Evaluation Committee
I-1. Components and some indicators of ecological resilience are revealed
I-2. Inter-relations between ecological resilience and the impact of human activities are revealed
I-3. Some sound options of the ecosystems and resources management are proposed
II-1. Quantitative measurement of spatial and temporal distribution of rainfall and its impact on household behaviors.
II-2. Quantitative assessment of households' dependence on various kinds of resources to mitigate rainfall risk and to cope with drought shock.
II-3. Quantitative evaluation of households' income as well as consumption smoothing as indices of households' resilience.
III-1. Complex processes of increasing and mitigating vulnerability will be analyzed in connection with local specificity.
III-2. The factors or combination of factors that work for mitigation of vulnerability will be disclosed.
III-3. The assumption that environmental degradation reflects a growing lack of synchrony between the society and its natural environment will be tested from the social resilience point of view.
III-4. It is hoped that we can suggest possible solutions to restore harmony to environment-society relations by strengthen community-based natural resource management institutions.
IV-1. The occurrence mechanism of natural disaster, human impacts of natural disaster and its rural communities influence will be clarified.
IV-2. The ecological system influences by environmental change, human influences of environmental change and historical and social background will be clarified.
IV-3. Functions of early warning system, their usefulness and practical problems for rural community will be clarified.
IV-4. The resilience index and mapping will provide the useful information for increasing resilience of rural communities in drought prone areas.

4. Common Issues and Discussions

4.1 Objectives of RIHN Project

A. Why do you conduct proposed research as a RIHN project?

As a RIHN project, it is possible to challenge research agenda that has never been accomplished in any other research funds. Relatively long term (6 years) with relatively large funds for one project makes it possible to realize such research. For our resilience project, those research agenda includes an experiment of forest-clearing, collection of soil quality and rainfall data at the large number of farm households. Since a research of resilience for social-ecological systems requires researchers from many disciplines, a support from RIHN to conduct interdisciplinary project is a large asset to initiate such a project.

B. Relations to “global environmental issues” and proposed research

People who rely their production on environmental resources have vulnerable livelihood against environmental variability. In those areas, deforestation, desertification, and soil degradation caused by a vicious cycle of poverty and environment degradation is a critical issue and it is recognized as one of the “global environmental issues.” The recent Environment Ministerial Summit (G-8) held in March 2005 called especially upon the need of research on impacts of climate change particularly in sub-Saharan regions. The proposed research aims at considering the impacts of environmental variability and increasing resilience of people in semi-arid tropics, which is the pressing global environmental issues for international community.

C. Research area and the relations to “global environmental issues”

The proposed research covers areas including Southern Africa region (Zambia, Zimbabwe), West Africa region (Burkina Faso, Niger), and South Asia (India). Those areas are a part of semi-arid tropics (SAT). In the semi-arid tropics (SAT) regions, the livelihood of the people is considered one of the most vulnerable against climate change. People in this area largely depend on vulnerable rainfed agricultural production systems and increasing food security, resilience of livelihood and reducing poverty are an acute issue in this area.

D. How do you utilize the results of the project to help solving “global environmental issues”?

We consider environmental degradation caused by the “vulnerability” of social-ecological systems as “global environmental issues” and the ways to enhance “resilience” of social-ecological systems as a primary goal of solving “global environmental issues”. During the research project, data collection, observation and analysis will be conducted to find out some key indicators to resilience. By using those indices, our goal is to provide some options of the ecosystems and resources management at the end of the project.

4.2 Methods to realize “integrated” and “interdisciplinary” project

A. Characteristics and problems of methods and organization

We plan to set four themes that interlink each other in various dimensions from household and community level analysis to temporal and spatial level of analysis. Particularly we invite social

scientists who are able to work with natural scientists to make use of scientific information and data for social science research agenda.

C. Research group expected to join the project

- Anthropometrics expert, macro economist, cultural anthropologist,
- India: water management and human security in Tamilnadu (Umetsu, Palanisami, Yatagai, Geethalakshmi, Sakurai and others from FY2006)

-The state of Tamilnadu is endowed with 5% of total land and a home of 7% of total population in India. About 60% of labor force in Tamilnadu engage in agriculture. Recently over exploitation of groundwater and water scarcity in tank irrigated area is becoming a major problem for the sustainability of agricultural regions. This research component aims at 1) analyzing the rainfall patterns in the state by accumulating the weather data of monsoon rain; 2) analyzing the flow of rainfall into the watershed by hydrological tool; 3) analyzing responses of farmers and communities for water scarcity; thus 4) consider measures to enhance resilience and sustainability of rural areas.

- Burkina Faso: soil resource management and human security (Tanaka, Sakurai and others from FY 2007)

-Soil resources in agricultural areas in Burkina Faso are under the threat of degradation because of various factors such as population pressure, intensified agriculture, and migration. We try to analyze various social and physical factors that are affecting soil degradation in resource poor rural areas of Burkina Faso.

C. Collaboration with other RIHN project

We plan to organize workshops in collaboration with other RIHN projects that share common interests and common research areas with us. Joint publication is also another option for collaboration.

4.3 Towards dissemination of the research outcomes

We want to disseminate the research results not only at the domestic meetings but also at the international research community. Therefore, possible strategies are as follows:

<u>Publication</u>

1. Publication of workshop report (annual)
2. Book publication out of international workshop (Japan, Zambia, and others)
3. Publication in the academic journals

<u>Presentation</u>

1. Presentation at the domestic and international workshop
2. Presentation and session organization at the international research community such as IHDP
3. Presentation and session organization at the academic conference

<u>Dissemination</u>

1. Make research results available at project homepage.
2. Make research results available at the open forum for public.

5. Reference List

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5.2 Publication of members

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1-3PR Project Member List (FY2006)

	Name	Affiliation	Department	Title	Field	Role
Leader	Chieko UMETSU	RIHN	Research Department	Associate Professor	resource & environmental economics	Regional analysis, farm survey
A	Shigeo YACHI	RIHN	Research Department	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
○	Ueru TANAKA	Graduate School of Global Environmental Studies, Kyoto Univ.	Terrestrial Ecosystems Managemenet	Associate Professor	agronomy	soil degradation and erosion
	Shozo SHIBATA	Graduate School of Global Environmental Studies, Kyoto Univ.	Landscape Ecology and Planning	Associate Professor	forest ecology	tree/shrub components and its succession
	Reiichi MIURA	Graduate School of Agriculture, Kyoto Univ.	Division of Agronomy and Horticulture Science	Lecturer	botany	grass/herb components and its succession
	Hidetoshi MIYAZAKI	Graduate School of Agriculture, Kyoto Univ.	Division of Environmental Science and Technology	Ph.D. Candidate	soil science	measurement of land plot, crop components
	Moses Mwale	Mt.Makulu Central Research Station	Ministry of Agricultre and Cooperatives	Chief Agricultural Research Officer	soil science	soil analysis
	Theme II					
○	Takeshi SAKURAI	Policy Research Institute, MAFF		Senior Economist	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
	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	Graduate School of Asian and African Area Studies, Kyoto University	Division of African Area Studies	COE Research Fellow	development study	village society and institution
	Shiro KODAMAYA	Graduate School of Social Sciences, Hitotsubashi University		Professor	African sociology	agricultural development and social change
	Kazuo HANZAWA	College of Bioresource Sciences, Nihon University	Department of International Development Studies	Professor	agricultural economics	farm household survey
	Chileshe Mulenga	University of Zambia	Institute of Economic and Social Research	Senior Lecture	Economics geography	analysis of socail behaivors
	Theme IV					
○	Mitsunori YOSHIMURA	RIHN	Research Promotion Center	Associate Professor	remote sensing	ecological change monitoring
	Tazu SAEKI	RIHN	Research Department	Assistant Professor	atmosphere physics	climate monitoring
	Chieko UMETSU	RIHN	Research Department	Associate Professor	resource & environmental economics	reginal analysis
	Megumi YAMASHITA	Survey College of Kinki		Lecturer	geographic information	vegetation monitoring
	India					
○	K. Palanisami	Tamilnadu Agricultural University	Water Technology Centre	Director	agricultural economics	household survey and analysis
	Akiyo YATAGAI	RIHN	Research Department	Assistant Professor	climatorogy	monsoon rainfall analysis
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	B. Chandrasekaran	Tamilnadu Agricultural University	Tamil Nadu Rice Research Institute	Director	agronomy	rice production analysis
	V. Geethalakshmi	Tamilnadu Agricultural University	Department of Agricultural Meteorology	Professor	agriculatural meteorology	monsoon rainfall analysis
	Burkina Faso					
	Kimseyinga Savadogo	University of Ouagadougou	Department of Economics	Professor	economics	household data analysis

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

Soil Resilience Study in Semi-Arid Sub-Saharan Africa

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Significance of Resilience

In semi-arid sub-Saharan Africa, droughts resulting in crop failure are common and have induced serious food insecurity that is closely interacted with poverty. Since the majority of poor make their living from smallholder farming under rainfed conditions, the land degradation closely linked with poverty and food insecurity prevails in rural areas. Rockström (2003) attributed the causes of land degradation to interacting pressures from population growth, poor land management practices and weak land policies acting on a vulnerable resource base. Land degradation reduces the capacity of the agricultural ecosystems to absorb environmental shocks, such as floods and droughts, that are projected to increase due to global climate change (IPCC 2001). As a result, we may have orthodox views that land degradation affects the considerable area of the Earth's land and the situation is getting worse as pointed out by the influential document '*Protecting Our Planet: Securing Our Future*' (UNEP/NASA/World Bank 1998).

However, several researchers argued the reality of those views. Scoones (1998), for example, carefully examined some of such doom-laden views and found that these views derived from two main sources: first, detailed scientific studies carried out at the microlevel whose findings are extrapolated to address wider issues; second, macrolevel economic analyses of food and agricultural policy which make inferences about longer-term trends from aggregate data at country, regional or even continental levels. Although non of the original studies cited in these views were, of course, incorrect, we should be aware of their data quality, the spatial scale at which the original studies were conducted, and the non-linear dynamics in time scale. Particularly, the last issue has been recognized as the key missing one in current investigations of agricultural resource management. Even if a trend over a short period in the recent past is observed, it cannot be assumed that such a linear pattern will continue into the future. Rockström (2003) pointed out that nature with which we are coping is not a balanced system filled with nice biogeochemical cycles, circulating in a predictable pattern, but instead consist of complex and adaptive systems, where extreme events, such as floods and droughts, form a natural part of the reality. Stocking (2003) also maintained that the linear view as doomsday scenarios of increasing population and declining soil resource quality fail to capture the diversity of soils. This perception reflects increase of our findings on the behavior of systems especially since Holling (1973) originated the idea of "resilience" in the field of ecology.

Among diverse definitions of resilience, two major ones are *engineering resilience* and *ecological resilience*. *Engineering resilience* is the speed by which the system returns to

the equilibrium after certain disturbance. As Bengtsson (2002) claimed, however, in ecosystem studies, the concept of ecological resilience seems more relevant since ecosystems are complex entities that have not only one but many stability domains. *Ecological resilience* can be defined as the capacity of a system to undergo disturbance and maintain its functions and controls and can be measured by the magnitude of disturbance the system can tolerate and still persist before it moves into a different region of state space and a different set of controls. Although resilience has often been discussed in the context of sustainability, it should be noted that a sustainable system possesses the resilience to disturbance, but not vice versa. Sustainability is commonly accepted as the desirable goal, while resilience can be desirable or undesirable. System states decreasing social welfare, such as racism or dictatorships, can be highly resilient. Since the semi-arid sub-Saharan Africa is fully exposed to the changing, unpredictable settings, such as drought and institutional instability, the resilience concept would help to analyze the interrelationship between agricultural land use, food security and land degradation.

Since the resilience can be defined theoretically as above, its operational and measurable definitions consistent with the theoretical ones are required for the analysis of systems in the real world. In this sense, we should specify what system state is being considered (resilience *of* what) and what disturbances are of interest (resilience *to* what) (Carpenter et al. 2001). Firstly, this paper reviews how the resilience concept has been used in the arena of terrestrial ecosystems with special reference to “resilience of what to what”. Secondly, it will discuss the context in which soil resilience should be evaluated in the semi-arid sub-Saharan Africa.

Experiences in Resilience Studies in Terrestrial Ecosystems

Most of the resilience studies in terrestrial ecosystems were categorized into two major groups according to the disturbances (resilience to what); manmade or natural. Examples for the manmade disturbances are logging (Asner et al. 2004), mechanical compaction by machinery (Munkholm and Schjønning 2004) and man (Lemauviel and Rozé 2003), contamination of metals (Griffiths et al. 2005) and organic chemicals (Benitez et al. 2004), grazing (Holm et al. 2005) and military training (Quist et al. 2003), while those for natural disturbance are wild fire (Certini 2005), flood (Jackson and Colmer 2005) and drought (Lloret et al. 2004). As for the system observed upon disturbances (resilience of what), they monitored the temporal changes in productivity of plant communities, function of soil microbial communities or soil nutrient status. In addition, the other attribute of the soil resilience studies can be type of the human interventions examined as impact on the change in resilience. One typical example is the comparison of organic and conventional farming systems in terms of the soil resilience to the certain disturbances (for example, Van Diepeningen et al. 2006; Griffiths et al. 2001). Thus, the soil resilience studies can be grouped according to the three attributes; what does affect resilience of what to what?

In spite of so diverse systems examined in terms of resilience from the scale of DNA (e.g., Fitter et al. 2005) to landscape (e.g., Holm et al. 2005), most of the authors have tried to describe the effect of disturbance on the functions of systems through diversity of their target, based on the hypotheses that the diversity of a system controls its resilience that might decline with improper human interventions. Van Diepeningen et al. (2006) reported that organic management resulted in higher numbers of bacteria of different trophic groups, larger species richness in bacteria and nematode communities and more resilience to a drying-wetting disturbance than conventional management. Griffiths et al. (2001) also found that the grassland soils and the organically managed soils with more protozoan populations were more resilient[1] to copper addition and heat stress than the polluted soils. As these studies reveal, the diversity appears to ensure the resilience of the system.

On the other hand, relationships between diversity and productivity or functionality are not apparently straightforward. Rosenzweig and Abramsky (1993) cited a number of the measurements showing the common trend that the diversity reached to the maximum at the middle level of productivity within a region (Fig. 1). Although its theoretical background has not been yet fully understood, Shinjo et al. (2005) discussed the application of this trend to evaluate desertification processes after extending the original hypothesis by Schlesinger et al. (1990) (Fig. 2). Thus, if both of the resilience and the productivity are controlled by diversity,

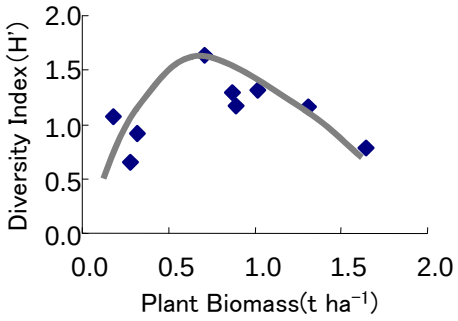

Fig. 1 Relationship between diversity index and plant biomass in northern Burkina Faso (Shinjo et al. 2005). At 9 sites, plant species were identified at intervals of 50 cm in the 50 m transect and aboveground plant biomass in 1 m^2 was measured at 3 points in the transect. Shannon-Weaver's diversity index, H', was calculated at each site by

$$H' = - \Sigma P_i \times \log_e P_i$$

where P_i is the frequency of plant species i in the 50 m transect. Plant biomass showed the maximum value at the middle of plant species diversity

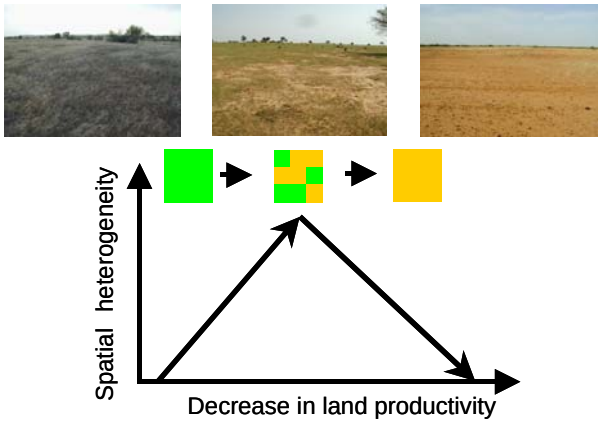

Fig. 2 Hypothetical diagram of desertification process (Shinjo et al. 2005). Spatial heterogeneity of soil and vegetation will reach a maximum at the middle of desertification processes, while soil and vegetation would in general have a homogeneous character at its beginning and end. Photos show landscapes found in northern Burkina Faso at the same sites in Fig. 1.

[1] In the original article (Griffiths et al. 2001), "resistant" was used instead of "resilient". They referred "resilient" to another feature of systems stability. This inconsistency in the definition of "resilience" among articles strongly suggests us to use "resilience" with explicit definition not to confuse readers.

tradeoffs between resilience and productivity might take place. The most resilient system would be at the middle level of productivity. This possibility should be examined carefully and thoroughly especially for the food security and the improvement of livelihood in the semi-arid sub-Saharan Africa. Food security system resilient to droughts or shocks might be achieved with investment of surplus in good years for stabilizing the system not for shifting to a second stable state.

Needs for Soil Resilience Study in Semi-Arid Sub-Saharan Africa

Recognizing the significance of the diversity in natural resources and also social capital for smallholder farmers in sub-Saharan Africa to mitigate disturbances, some authors called for its analysis to provide more realistic intervention for them (Scoones 1996; Stocking 2003; Rockström 2003). There is missing area for this analysis. Firstly, few studies have defined resilience as operational and measurable indices. For example, Rockström (2003) proposed water harvesting and conservation farming as options of resilience building for drought mitigation, but did not specify how to evaluate their effectiveness yet. Secondly, dynamic nature of spatial variability in complex systems has rarely been elucidated at field or landscape level although diversity in time and space might contribute to the resilience of the system (Fig. 2). Scoones (1998) exemplified how farmers in Ethiopia managed space at field and plant level in order to maximize the efficiency of use of fertility amendments. For this purpose, experiments that can distinguish effects of human intervention on soil resilience from those of disturbance would be promising since disturbance itself also affects soil resilience. Thirdly, relevance of soil resilience in the context of social systems is not examined yet. Smallholders do not only rely on soil resilience for mitigating disturbance. Social resilience also plays a significant role. Reciprocal help among different ethnic groups

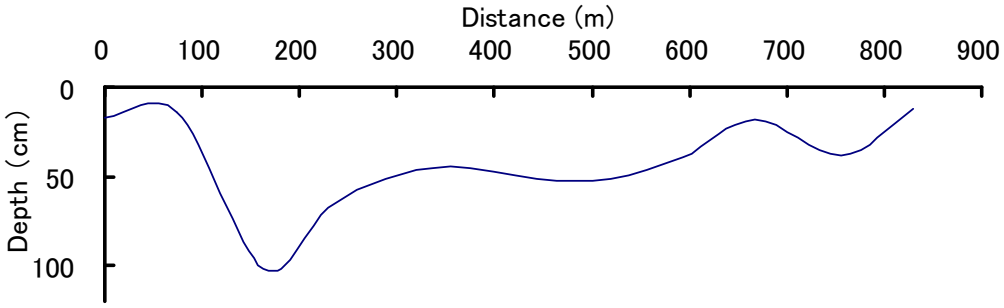

Fig. 3 Spatial pattern of the depth of petroplinthic horizon along a transect in a village of central Burkina Faso (Tanaka unpublished data). A petroplinthic horizon is an indurated layer, in which iron is an important cement (FAO, ISIRC and ISSS, 1998). Since this horizon is extremely hard, its depth corresponds to the effective soil depth in terms of plant productivity. This depth could be more critical in drought years than in normal years since the soil thickness down to this horizon determines the amount of water that can be held in the soil. Thus, the depth of petroplinthic horizon can be one of the indicators for soil resilience to the drought in this study site. This spatial pattern was mainly determined geomorphologically, but could be modified by human-induced erosion.

and family members living in the different regions is an good example. Social resilience is also not static, might be eroded due to both of land degradation and socio-political change. Decline of soil resilience would trigger a loss of social resilience and vice versa. Dynamics in soil resilience should be evaluated in the context of social resilience.

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Analyses of Household and Community Responses to Environmental Variability: The Case of Drought in the Semi-Arid Tropics

(Report on Feasibility Study in 2005)

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Household and Community Responses to Drought

Rural households in the semi-arid tropics, particularly in sub-Saharan Africa where credit and insurance markets are generally imperfect, have developed various kinds of risk-management and risk-coping mechanisms to respond unpredictable rainfall.[1] Some of the mechanisms such as borrowing and gift-receiving depend on relatives and friends in the same or neighboring villages, and hence the informal mechanisms will not work well in the case of severe drought where most of the households are simultaneously affected.[2] On the other hand, there are other kind mechanisms that rely on natural resources; for example, food gathering in the bush and utilization of wet valley bottoms.[3] As such, which mechanisms a household utilizes and how much extent the mechanisms are effective will be determined by private assets that the household has, common-pool natural resources that are available for the household, the severity of the drought, community's characteristics, and so on.[4] At the same time, the natural resource endowments could be affected by rural households' behaviors to cope with droughts. For example, if many households rush for wild food in the bush, the

[1] A detailed review about research on informal insurance mechanisms in developing countries is available in Chapter 8 of Bardhan and Udry (1999). It shows that rural communities have mechanisms to pool idiosyncratic risks incurred at individual households, although they are not perfect.

[2] In the semi-arid zone in West Africa, a drought-prone area, it is known that rural households have diversified their income sources to zones (i.e., the forest zone) and sectors (i.e., non-agriculture) that are not subject to the erratic rainfall in the semi-arid zone. For example, rural population in Burkina Faso relies on external migration (mostly to neighboring Côte d'Ivoire) as well as remittance from the relatives living outside the country, and such revenue is estimated to constitute 10 – 20 percent of their total income (Reardon et al. (1988)). It is not only drought but war, economic crisis, earthquake, flood, etc. that will cause a covariate shock from which many people in the same area suffer at the same time. There are limited number of studies on households' coping behavior in the case of covariate shocks: for example, the impact of the currency crisis on fertility in Mexico (Mckenzie (1999)), households' coping with flood in Peru Amazon (Takasaki et al. (2004)), the impact of the Great Hanshin-Awaji earthquake on households' expenditure (Sawada and Shimizutani (2004)), and the impact of war-induced covariate shock on soil fertility management in Burkina Faso (Sakurai and Savadogo (2006)). Please note that the concept of socio-ecological resilience is not limited to the case of drought, but can be applied other covariate shocks.

[3] In our preliminary fieldwork in Zambia we observed that people in the area affected by the severe drought in 2004/05 consume wild food such as cassava-like poisonous root. Such phenomena are often reported, but it is not yet known how much nutrient share such wild food constitutes.

[4] Of course, formal institutions play an important role in the determination of households' strategies of *ex ante* risk-management and *ex-post* risk coping. In our preliminary fieldwork in Zambia we observed a lot of aid (food as well as agricultural inputs for the next season) are being distributed in the drought-affected area by the government and NGOs. We can imagine that such aid may have created a moral hazard among farm households in the drought-prone area, although it must be rigorously proven by the data. In fact, farmers would not shift from maize to other drought-resistant food crops such as sorghum and cassava even though maize harvest totally failed in 2004/05 due to the drought. We believe that the moral hazard can explain farmers' crop choice at least partially.

resources will be exhausted and will not serve as a safety net in the next drought.[5] In other words, the resilience of households and that of ecosystem are dynamically inter-reliant. And because of this inter-reliance, households in the semi-arid tropics are often trapped in the vicious cycle of poverty and environment degradation.[6] This is the fundamental issue that the research project at which this feasibility study is aiming will address. Hence, this report on the feasibility study proposes a strategy to analyze socio-ecological resilience coupled with some review on the literature.

The research strategy consists of four parts. Part 1 discusses how to measure the risky event objectively, that is, rainfall. Then, part 2 concerns the endowments of resources available to households including physical, natural, human, financial, and social capitals. Part 3 is devoted to the analyses of households' behavior: risk-management before the rain, adjustment during the rainy season, and risk-coping after harvest. And finally in part 4, households' resilience in risky environment is evaluated in terms of income-smoothing, consumption-smoothing, and nutritious status.

1. Measurement of spatial and temporal distribution of plot-level rainfalls

It is well known that in the semi-arid tropics rainfall variability is very large even within a village. Moreover, crops are severely affected if there is no rain in the critical stage even annual rainfall level is high enough. That is, both spatial and temporal distribution of rainfall does matter. Nevertheless, most drought studies use annual rainfall observed at regional weather station, simply because spatial and temporal rainfall distribution at plot-level cannot be observed. This is the most significant weakness of existing drought studies. Hence, as the part 1 strategy it is proposed that daily rainfall on every sample household's plot will be recorded by utilizing small rain gauges, and the characteristics of spatial and temporal rainfall distribution within a small area will be analyzed.

Plot-level rainfall data have never been utilized in economic studies except for a pilot-type study done in semi-arid zone in southwestern Mali with a small number of sample households (Sakurai 2005a). Although sample size of the proposed study will be much bigger the pilot study in Mali, it will be useful to describe the Malian study briefly here so that the data collection method can be understood. In the Malian study, two villages are

[5] In the case of war-induced covariate shock in rural Burkina Faso, the negative income shock has induced an expansion of cropping area (Sakurai and Savadogo (2006)). This can be considered as the case where natural resources (soil and vegetation in bush) are exploited for coping with the shock, and if it leads soil degradation and desertification, the resources will never serve as safety net. Obviously, it depends on the robustness of soil and vegetation against human interventions.

[6] Although the vicious cycle of poverty and environment degradation is frequently mentioned (for example, a review by Duraiappah (1998)), its empirical evidence is still poor due to the lack of data and most of the existing empirical studies show only static relationship between the two (e.g. Cavendish (2000)). The difficulty may arise from two characteristics of the nexus. First, resource degradation induced by chronic poverty is slow and gradual, and hence is hardly observable. Second, chronic poverty itself may not cause resource degradation if the nexus is at a stable equilibrium point. Hence, the study being proposed here aims to overcome the data constraints in a multidisciplinary research team.

chosen for the study site and in each village about 30 households are randomly selected from wealth-based strata. Hence, the sample size is 60 households in total. The sample households were interviewed by field assistants who stayed in each village. They used structured questionnaires prepared in advance, which consist of several components listed in Table 1. Field assistants residing in each of villages interviewed the sample households every week starting from May, 2001 until the end of year 2003. On the other hand, about half of the sample households were selected for the measurement of plot-level rainfall. For each household, the most important plot in terms of food production was identified and an automatic rain gauge was set on the plot. Hence, the number of the rain gauges amounts to fifteen in each village. They did not select all the sample households for the rainfall measurement just because of the limitation of budget. Based on the data of daily precipitation at fifteen different locations in a village, daily precipitation levels at another fifteen plots of the remaining half of the sample households were estimated.

For rural households, rainfall is the most precious natural resource for their subsistence. Therefore, plot-level rainfall can be regarded as "private asset" for the owner of the plot. However, since rainfall availability is not predictable unlike other assets, rainfall should be classified as a risky asset, which does not appear in Table 1.

Table 1. Components of Questionnaires for Household Survey in Mali

Category	Frequency	Description of component
Household characteristics and household asset holdings	Once a year: At the beginning of the rain season	Demographics of the household
		Plot characteristics and crops (household common plots only)
		Ownership of the plots investigated
		Livestock holdings
		Asset holdings (agricultural equipment and buildings)
		Information sources of agriculture and technology
Agricultural activities	Every week: During cropping season	Agricultural activities conducted during the previous week
		Agricultural inputs and outputs during the previous week
		Purchases and sales of agricultural products during the previous week
Expenditures	Twice a month: During the survey period	Expenditures for goods and service during the last two weeks
Non-agricultural activities and transfer	Once a month: During the survey period	Consumption of food in stock during the previous month
		Labor supply to and income from off-farm activities during the previous month
		Gift given and received during the previous month

Adapted from Sakurai (2005a)

2. Investigation of households' capital endowments

How a household manages drought risk and copes with drought is a function of not only the magnitude of drought shock but also the resources available to the household. As mentioned in part 1, rainfall is also considered to be an asset, and can be included in the households' asset inventory. But since the measurement of plot-level rainfall is quite new and requires innovative technologies, it is treated separately in part 1. Therefore, in the

strategy part 2, households' capital endowments other than rainfall will be investigated.

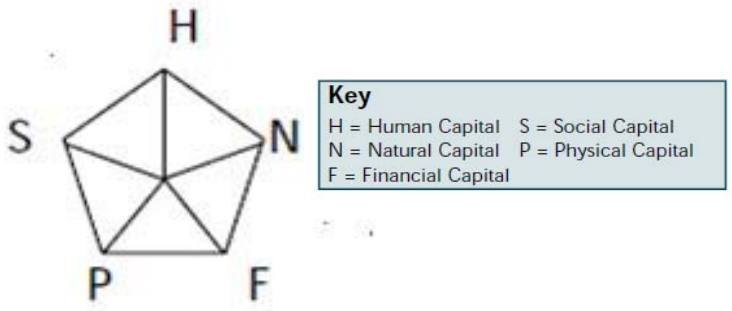

Figure 1. Five Capitals in SL Approach adapted from Ashley and Carney (1999)

UK's Department for International Development (DFID) is promoting the concept of "Sustainable Livelihood (SL) approach" for poverty alleviation, in which households' capital that supports their livelihoods is classified into five categories as shown in Figure 1 (Ashley and Carney 1999). This paper does not necessarily follow the SL approach, but adapts the categorization of households' capital as it is quite convenient. In the context of this proposed drought study, households' capital could be classified as follows: natural capital (rainfall, agricultural land, fallow land, forest land, livestock, and so on), physical capital (agricultural equipments, houses, and so on), human capital (composition of household members, their education level, their skills, their health status, and so on), financial capital (potential money-lenders, potential gift-givers, saving, and so on), and social capital (membership, network, trust, and so on).

There are several methodological issues in the measurement of the capital endowments, which are not explicitly treated in the Malian study presented above. First issue is how to measure the risk. As mentioned in part 1, since rainfall is a risky asset, the measurement of spatial and temporal variability of rainfall is critical. Similarly, it is necessary to quantify the risk of other assets, particularly of risky assets such as livestock holdings and human capital that are subject to diseases and death.[7,8] In other words, simple information on the number and the value of animals and the number of years of attending the school is not enough as they do not reflect their vulnerability. As far as the author knows, there is no standardized method to measure it or proxy variables to capture it, multidisciplinary research team including experts in human health and animal health should elaborate to develop methodologies.

Second issue is how to measure the physical amount of natural resources. Even though most assets are not so variable in the short-run, they are subject to depreciation in the long-run. The depreciation is determined by several factors including the utilization by the people, and

[7] As is well known, HIV prevalence rate in Zambia is very high even in rural area (about 15% according to UNAIDS/WHO (2004)). It means that human capital cannot be an effective asset to cope with external shocks such as drought. In addition, households may be discouraged to invest in such a risky asset, which will have a serious, negative consequence in the long run not only to the households themselves but also to the country as a whole. This is one of the most important research topics of this proposed study in Zambia. Yamano (2005) deals with this issue in his study in Kenya.

[8] Livestock diseases are a serious problem in Zambia. For example, in March 2004, outbreaks of contagious bovine pleuropneumonia (CBPP) were reported in southern and western provinces of Zambia (FAO 2004).

we know that soil is degrading and forest is disappearing. However, it is not easy to measure the rate of their depletion and the rate of their renewal. Moreover, it is hardly obtainable how much amount of resources exists and is available. The difficulty in measurement arises particularly when we consider the way to analyze data. Since this proposed study concerns household behavior under drought risk, the unit of analyses should be plot and household. Hence, just like plot-level rainfall, the endowments and the depreciation of natural capital need to be plot and household level. Such measurement may be technically possible, but will require tremendous amount of fieldwork. Thus, efficient methods to obtain necessary information need to be developed in collaboration with natural scientists. Note that the Malian study presented in part 1 does not include such natural resources in the capital inventory available to the households, as shown in Table 1. It is not because they are insignificant, but because it is too costly for a non-specialist to conduct physical measurement of soil and vegetation. The advantage of multidisciplinary approach of this research project is the involvement of natural scientists in the physical measurement such as soil and vegetation.

Third issue is about social capital.[9] A standard method to measure social capital by a set of questions has been established by the research team at the World Bank (Grootaert and Bastelaer 2002a; Grootaert et al 2003). And there is an ample of empirical studies that show positive effect of social capital on household income, technology adoption, common-pool resource management, etc. (for example Grootaert and Bastelaer 2002b; Grootaert et al 2002; Isham 2002; Krishna and Uphoff 1999). However, there are several problems if we adapt the standardized World Bank methodologies. First, although the World Bank questionnaires are comprehensive, they include so many questions and take so long time that they cannot be readily adapted in our study on socio-ecological resilience that should require a lot of different kinds of data. From a technical point of view, this is the most serous weakness of the World Bank approach. Moreover, there is still even a fundamental question as to how we can measure social capital. As Fukuyama (1999) points out many of the measurement of social capital such as trust, networks, civil societies are manifestations of social capital arising

[9] Bourdieu (1986) defines social capital as "an attribute of an individual in a social context," and syas "One can acquire social capital through purposeful actions and can transform social capital into conventional economic gains. The ability to do so, however, depends on the nature of the social obligations, connections, and networks available to you." It means that social capital, just like physical capital and human capital, is accumulation of past flows of investment less past flows of depreciation and somehow measurable. There are several ways to classify social capital, but with respect to the elements, two forms of social capital that correspond to the different roles of community should be distinguished. According to Krishna and Uphoff (1999), there are structural forms of social capital and cognitive forms of social capital. The structural social capital includes "rules, social networks, roles, procedures that facilitate mutually beneficial collective action by lowering transaction costs, coordinating efforts, creating expectations, making certain outcomes more probable, providing assurance about how others will act." On the other hand, the cognitive social capital means "norms, values, attitudes, and beliefs which create and reinforce positive interdependence of utility functions and which support mutually beneficial collective action."

as a result of social capital rather than social capital itself. Sobel (2002) addresses a causality issues in which he argues that some consequences of social capital are used as measurement of social capital itself in other context. Since there is no agreement regarding the measurement, or some even deny the existence of social capital as a kind of capital that individuals or households possess, this proposed research project need to consider how to incorporate the concept of social capital in the framework of socio-ecological resilience. Probably, one way to incorporate it will be from the viewpoint of social safety net that "social capital" may be providing communities or households. Such roles of social capital have been recognized, but empirical evidence is still little except for Sakurai (2005b) who shows that villages in Burkina Faso with higher social capital measured by group activities within the villages received more external aid when villagers suffered negative income shock due to the civil war in Côte d'Ivoire.[10]

Finally, we need to pay seroious attention to the property rights of the capital items. In the case of natural resources, resource ownership is often analyzed in terms of efficiency and equity: for example, which type of forest ownership is more efficient and which is more equitable, state property, common property, or private property? There are bunch of empirical studies in this field (e.g. Otsuka and Place 2001), but they are not investigated from the view point of socio-ecological resilience. Moreover, in the case of household capitals, gender related questions are typically addressed: whose capital (for example, land) is it, who controls the capital, who obtains the income from the capital, and so on. The biased asset ownership arises via gift and inheritance in the case of physical capital like land or by investment in the case of human capital like education. For example, see Quisumbing et al. (2004). Again, their consequences on socio-ecological resilience are still unknown. Compared with other types of capital, the ownership of social capital and its consequences are rarely discussed in the literature. There should be difference between the case where male household head has a network with outside and the case where his wife has a network with outside, in terms of social safety net, income generation, etc.

3. Analyses of households' behavior against rainfall variability

Given the various kinds of capital endowments discussed in parts 1 and 2 above, the question in part 3 is how households in the semi-arid tropics behave under the risky environment. Household behavior can be classified into three categories: risk management before the rain, adjustment during the rain season, and risk coping after the harvest. It is schematically summarized in Figure 2. At the beginning of the rain season, the household,

[10] With this regard, another way of classification of social capital may be useful. According to Narayan (1999) there are two types of social capital: bonding social capital and bridging social capital. The former works within groups to facilitate cooperation and/or collective action among members, while the latter improves the access to outside such as market, NGOs, and government. The bridging type of social capital is considered to facilitate the construction of social safety net with outside the community.

knowing the level of capital endowments as well as their risk (including the expected level of rainfall), makes decisions as to agricultural inputs, off-farm labor supply, livestock and other asset transaction, borrowing/lending, gift-giving/receiving, expenditure, consumption, and so on. With respect to agricultural inputs, crop and plot diversification is known to be one of the important strategies to mitigate rainfall risk. They include crop choice (e.g., drought-tolerant crops or drought-susceptible crops), varietal choice (e.g., early maturing or late maturing), and technology choice (e.g., with tillage or without tillage).

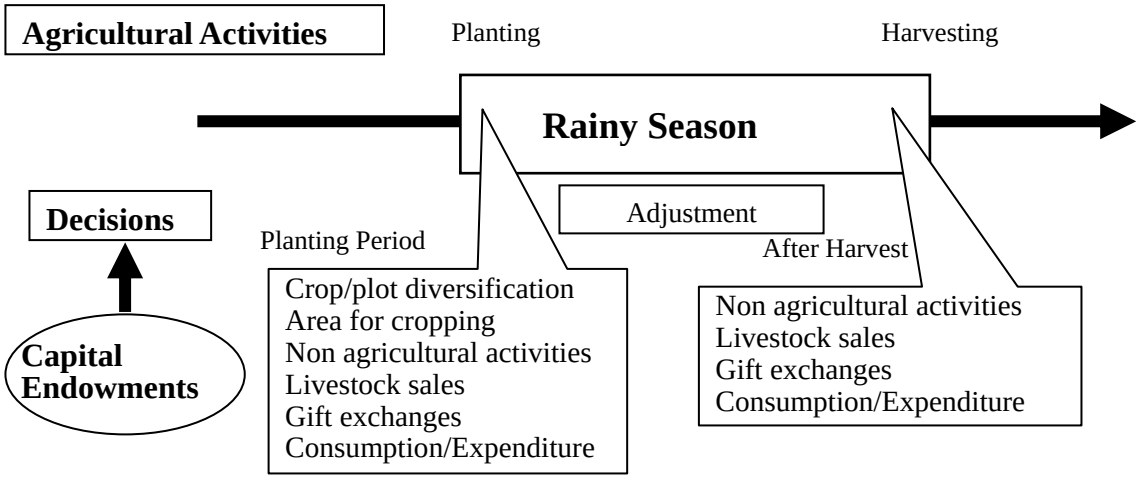

Figure 2. Household's Decision Sequence in the Semi-Arid Tropics

Then during the rain season, the household adjust its behavior with knowing the level of rainfall already given and modifying the expectation of the amount of rainfall still coming. Finally, after crop harvesting, the household decides how to cope with the results of the cropping season. If the realized income is less than the expected level, the household will do seasonal migration and off-farm labor supply as well as sales of some of capital endowments more than usual. Moreover, if such coping is not enough or expensive, the household will try to obtain income from natural capital (consuming and selling natural products such as wild fruits, fuelwoods, wild animals, and so on) as well as social capital (receiving personal gifts and/or loans and external aids from NGOs and government).[11]

The analyses in the proposed study will require detailed data about household behavior throughout the year. Such data will be collected by repeated household interview, at least once a week, considering that people easily forget about the details of their own behavior.

[11] As Solow (1999) points out, with this regard, social capital differs from natural or physical capital as the former does not depreciate or even appreciate when the owner utilizes it. Moreover, one cannot transfer social capital from one person to another, or one cannot liquidate social capital unlike natural or physical capital (Arrow 1999).

The household data will be matched with the daily, plot-level precipitation explained in part 1 and be used to investigate how households adjust their subsistence strategies to the varying environment during the rain season. Since such a study is very rare due to the limitation of available data, this proposed study is going to pioneer it.[12]

4. Evaluation of households' resilience

Finally, the performance of households' risk management and coping behavior will be evaluated from the viewpoint of resilience. Ignoring ecological aspect for a moment, the most standard criteria of households' resilience in economics is income smoothing and consumption smoothing as (see the review by Udry and Bardhan 1999): that is, a household with resilience can reduce risk *ex ante* by diversify income sources and can mitigate income shock by *ex post* coping, and consequently its income and consumption are little affected by the shock. Income and consumption smoothing should be evaluated not only within a year (i.e. seasonal variation) but also over years (i.e. yearly variation due to the rainfall), and therefore data collection from the same households need to be done several times within a year (ideally weekly) and over years during the project period.

However, there are several issues to consider. First whose consumption should be smoothed? Other than the capital endowments discussed in part 2, the discussion so far assumes implicitly that a household is the basic unit of decision making. But it is frequently observed in developing countries that individually earned income is not pooled in a household, and the allocation of consumption goods such as food within a household is biased (e.g., Quisumbing and Maluccio 2000).

Second is how to physically measure the income and consumption. Theoretically, it is not the monetary value, but utility derived from consumption and leisure that should be smoothed over time (taking the discount rate into account, of course). But because we cannot observe utility, instead of utility itself, income and consumption in monetary terms are used in empirical studies. However, in rural areas in the semi-arid tropics, monetary values may not be a good indicator of utility, for several reasons. First, just technical, the monetary values of wild food that people consume in case of crop failure may not be properly evaluated. Related with the first point, if the non-market prices of such products are very high as they are scarce, we may have to conclude that households' consumption in monetary terms is smooth even under the drought shock. It may not be correct.[13] Hence, in addition to the monetary

[12] The flexibility of households' farming practices during the rain season is one of the most important research topics of the JIRCAS's research project in Mali (see Caldwell et al. 2005). But Sakurai (2005a), using the same data set as Caldwell, analyses only ex ante risk management and ex post risk coping. Fafchamps (1993) also focuses on this issue, and examines the adjustment of labor supply in Burkina Faso.

[13] Not only the evaluation problem, but also there are questions as to the discount rate and the form of utility function. Namely, are the subjective discount rate and the form of utility function constant over the periods? If they change during the crisis period, how can we incorporate it in the analysis of consumption smoothing?

terms, we will need to see total calorie intake and its smoothness over time. For this purpose, physical measurement of in-kind income and food consumption (weight, volume, and calorie) is required for the evaluation of resilience.

Related with the above, required calorie may vary depending not only on age, gender, and body weight, but also on the level of activities. Naturally, those who work physically hard demand more food. It means that although basic calorie requirement can be considered fixed in the short-run (assuming that body weight does not change so much), real requirement depends on how much he/she consumes the calories, and hence endogenous. Putting it in other way, those who suffer from starvation will not work hard so that less calorie should be required to survive. In other words, the reduction of food consumption as well as activity level is a household strategy to cope with negative income shock. The question is if we regard it as a successful case of smoothed consumption as the required level itself is reduced, or as a case of failed consumption smoothing as the consumption level becomes low. Either way, if we have to take this issue seriously (I think that we should do it), we need to measure people's activity level and estimate their calorie consumption, and conduct anthropometrics: namely the measurement of body weight and height. Furthermore, if possible, we need to have a medical doctor check health condition of all the people in the sample households.

Conclusions

To achieve the proposed study, a huge amount of data will be required. Therefore, excellent collaboration in the multidisciplinary research team as well as sufficient amount of funding are indispensable.

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How Can We Perceive Social Vulnerability: Rethink from a Case Study on the Impact of Infectious Disease on Agricultural Production in Zambia

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I. Introduction

The importance of vulnerability as a notion to comprehend the cause of famine and poverty has been widely acknowledged. In spite of difficulty to define the meaning of it, the vulnerability has become one of indispensable notions that is necessary to discuss about eradication of poverty, self-help development, formation of social capital, self-governing institutions, sustainable development and etc. The emerging concept of 'social resilience' has also strong connection with vulnerability, because most of social resilience has to do with reduction of vulnerability of society. The concept of social resilience means the process of recovery from any destructive conditions that were brought in society. Social resilience has relation to both natural disaster and socio-political upheaval. The paradigm shift type of social change is in the scope of resilience study. But social resilience relate to paradigm shift should be discussed completely different from that without paradigm shift. In this paper I will be handled only the case of non-paradigm-shift type of social resilience[1].

As Blaikie et al. (1994) noted to define vulnerability is not easy. They showed an example about the impact of new road on the vulnerability of previously isolated rural communities. Saying that the new road may help to reduce the vulnerability of the community in times of drought but at the same time it may serve to increase vulnerability through evacuation of able-bodied youth out of the community that caused decrease in production (Blaikie et al. 1994; 16).

I want to discuss in this paper first about complexity of vulnerability, and then to propose some significant points to be noticed when we discuss about vulnerability. Some definitions have been proposed; Chambers (1989) defines vulnerability as the exposure to contingencies and stress, and difficulty coping with them. And he suggests that there are three co-ordinates of vulnerability; the risk of exposure to crisis, stress and shocks, the risk of inadequate capacities to cope with stress crises and shocks, and the risk of severe consequences of and from crisis, risk and shocks. Blaikie et al. (1994) have defined from the natural phenomena point of view that vulnerability is the characteristics of a person or group in terms

[1] The restoration of 'normality' does not always mean reduction of vulnerability. It may sometimes strengthen a structure that may reinforce deep-rooted causes of chronic increase of social vulnerability (Blaikie et al. 1994; 196).

of their capacity to anticipate, cope with, resist, and recover from the impact of natural hazard.

There still remain some points to be discussed and examined for definition, however it is not aimed at refining the definition in this paper but tried to note some significant points relevant to the further discussion on vulnerability. I will take an example based on my field study done in Zambia about the impact of excessive death of people on the vulnerability of individuals and of families.

II. HIV/AIDS study and social vulnerability

There are no doubt that prevalence of HIV/AIDS has strong impact on people's daily life and that has increased vulnerability of some of individuals and families. The importance thing is to anatomize the process of increasing vulnerability and to discern the variety of nature of vulnerability. Most of HIV/AIDS studies do not directly refer to social vulnerability, however most of them have something to do with it more or less.

Many studies have done to assess the direct and serious effects of HIV/AIDS from medical, nutritional, and economic points of view. Among them study on effect indirect and slow are relatively scarce, as these effects are very complex and difficult to discern. Barnett and Whiteside (2002, 161) suggested that the impact of an infectious disease should be seen as a continuum between an acute shock and slow, profound changes. We should therefore pay more attention to the indirect and slow effects of diseases in addition to the direct impact that is made. For this purpose it is necessary to conduct a long-term field study.

The effects of diseases that emerge slowly and indirectly occur at different community levels, e.g., at the level of an individual household, a whole community, or an entire nation. Because such effects affect different societies in different ways, we can only understand them in the context of certain social settings. Illness and death affect not only the health of individuals but also the well being of each household. In rural societies where agricultural production is the principal economic activity, the impact of disease on agricultural production can constitute a critical problem. In this paper it is aimed to evaluate the effects of novel infectious disease on agricultural production.

Special attention is paid to the dispersion of vulnerability through a mutual help system. In the context of agricultural production, the mutual help system normally functions to assist individual farmers by mitigating the effects of labor or equipment shortages may be jeopardized by unprecedented high rates of people's death. And the high rate of death is relates to prevalence of infectious disease.

This study was conducted in Zambia in a rural village located about 90 km north of the capital city of Lusaka (Figure 1).

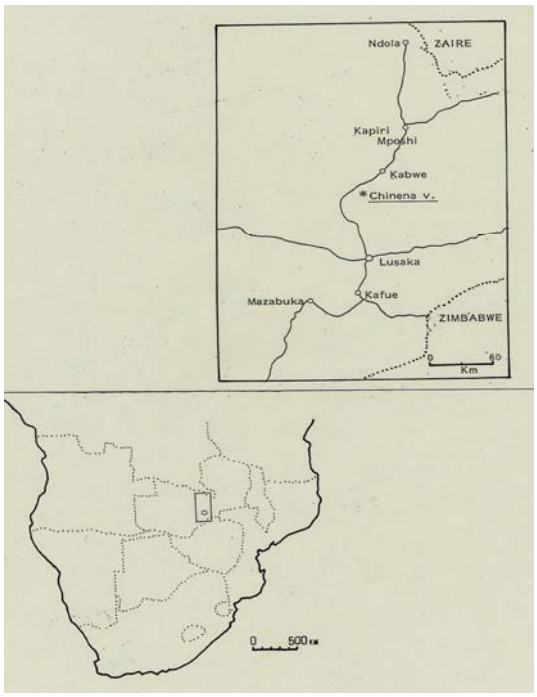

Fig. 1: Location of study area

III. Prevalence of infectious disease

I have investigated changes in the agricultural production system in the study village (referred to hereafter as village "C") since 1993 (Shimada 1995, 2000). Agricultural production in this village has changed remarkably and has been subject to the influence of rapid socio-economic changes in Zambia. However, only recently did realize the serious impact infectious disease has had on the village. Several households have shown an extraordinarily high death rate among adults, although this high death rate has not yet become prevalent across the whole village. However, when these few cases are examined more closely, it is apparent that a high death rate within households could become a serious concern to farming.

The intent of this study was not to identify the prevalence of HIV/AIDS in the village, although I consulted one medical doctor on the possible presence of HIV/AIDS in the village. She visited the village twice in February 2002 to conduct interviews. Although she was reluctant to positively identify the disease without a formal HIV test, she conceded that there was high probability of HIV/AIDS prevalence in some of the interviewed households[2]. The household described in this paper, as a case study with unprecedented high death rates was one of those families. In this study, I assess the impact of high rates of illness and death on agricultural production.

[2] The World Organization (WHO) has estimated that about 28.1 million people in Sub-Saharan Africa are infected with HIV/AIDS. WHO has also estimated that in 16 African countries, at least 10% of people aged 15-49 are infected; in Southern Africa, at least 20% of the population in this age group are infected (WHO 2001, 16); AIDS has thus become the biggest threat to people in southern Africa.

IV. Agricultural production: Two types of farming practices

Village C was established in the late 1960s and its population increased rapidly for a number of reasons. The first head of the village, who died in 1981, welcomed new people into the community, regardless of their ethnic origin. Wetland (*dambo*) cultivation also attracted new settlers to the village, and the introduction of the Structural Adjustment Program in 1983 accelerated this movement.

Figure 2 illustrates the increase in the number of households that cultivated *dambo* farms. This figure reflects the increase in the total number of households in the village, as almost all the

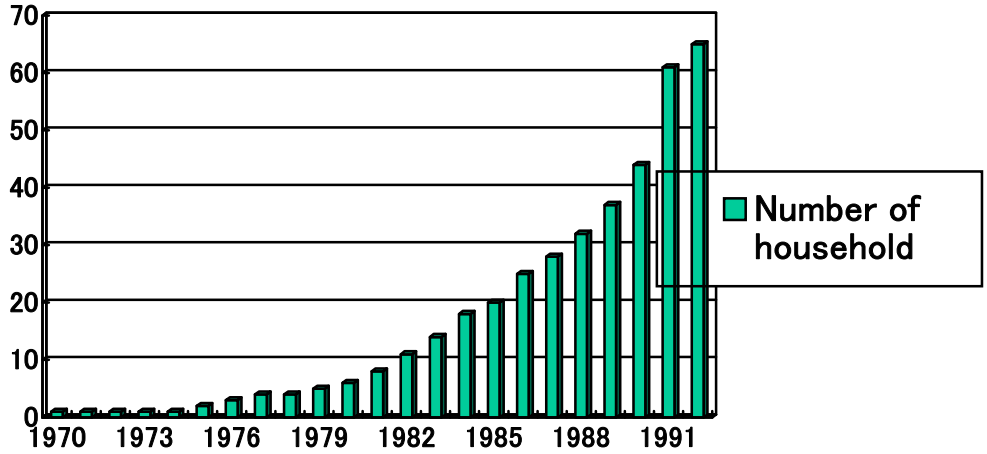

Fig. 2: Population increase in the village C

people who had migrated to the village before 1991 were able to access *dambo* land. In total, village C consisted of about 120 households in 1998[3]; at this time, most farmers cultivated *dambo* land.

This study was based on an intensive investigation of fourteen households that were located near *dambo* K, one of most fertile *dambos* in the village (Figure 3). Of the four *dambos* in the village that were developed for cultivation in 1991, d*ambo* K was the first. Some households migrated from Zimbabwe to the vicinity of the *dambo*. One of these households was the first one to initiate *dambo* cultivation in the village, and as Figure 2 shows, *dambo* cultivation gained popularity in the 1980s.

Two types of farming take place in the village: upland maize production during the rainy season (December to April) and vegetable cultivation in the *dambo* during the dry season (Figure 4). For most farmers, upland maize production is the most important agricultural practice, as maize is a staple food. The cultivation of crops such as tomatoes, watermelons, and

[3] In 1993, there were about 110 households. Between 1992 and 1998, on average about five households left and seven households immigrated every year. (Kodamaya 2000, 129)

rape on *dambo* farms is a very important way in which cash income is generated. For some

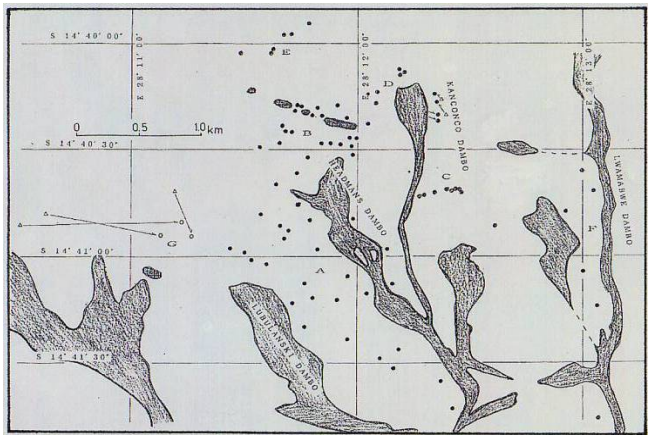

Fig. 3: Distribution of *dambos* in the village

Dambo	Dambo farm	Upland farm
	Tomato	Maize
	Water Melon	Tomato
	Rape	Water Melon
	Sweet Corn	Cotton

Fig. 4: Schematic land use in the *dambo* and upland

farmers, the estimated amount of production from *dambo* farming has far exceeded that of upland cultivation (Table 1). These farmers have become more and more dependent upon *dambo* farming as a way of increasing their cash income and as a means of strengthening their economic base by diversifying their products.

The cultivation practices of these two agricultural systems are quite different.

Table 1: Estimated gross output of upland and *dambo* farms

(Upper row: January to August, 1993)

(Lower row: January to August 1994) 1000Kwatcha

Farmer	Upland farm			Dambo farm (a)			Total (b) [(a)/(b)]
	maize	tomato	water-melon	maize	tomato	water-melon	
1	66 82	32 96	- -	- -	180 280	- -	278[65] 458[61]
2	45 68	53 14	48 36	30 45	90 288	- -	266[45] 451[74]
3	90 30	20 20	- 5	- -	22 64	- 34	132[17] 153[64]
4	80 30	4 -	- -	- -	7 151	1 -	92[9] 181[83]
5	82 97	20 -	- -	- -	60 -	- -	162[37] 97[0]
6	50 60	32 128	6 -	- -	14 -	- -	102[14] 188[0]
7	n. a. 12	n.a. 18	n.a. 22	n.a. -	n.a. 32	n.a. 19	n.a. 103[50]

Maize production is calculated by the estimated number of bags (90kg) produced.

Other vegetable production is estimated by calculation as follows:

Tomato: [number of box] x [price per box]

Rape: [number of bundle] x [price per bundle]

Water Melon: [number of bag (90kg)] x [price per bundle]

The price of vegetable was so changeable that average price of each week was adopted in case farmers did not remember the real price. The weekly average price was calculated by reliable prices interviewed.

Individual households, each of which consists of a husband, wife/wives, and children, cultivate *Dambo* farms. Widows or divorced women with children sometimes cultivate *dambo* farms on their own. Mutual help in *dambo* cultivation from members outside the household is not common.

In contrast, upland cultivation of maize is carried out by a big farming unit, i.e., a cluster of households that consists, mainly, of an extended family. Many farmers cultivate tomatoes in upland farms, but maize is the mainstay crop in the fields. Tomato cultivation in

upland farms usually begins after the end of maize cultivation.

Maize production is still the most important activity for most villagers; however, the abolition of maize procurement in 1993 weakened the confidence of farmers in maize, and vegetable production on *dambo* farms has become increasingly important (Shimada 1995).

V. Group farming on upland fields

Both upland and *dambo* cultivation are affected by illness and death. However, because of differences in cultivation practices, the extent to which each type is affected by illness and death differs. Here, I outline group-farming practices in upland agriculture.

Groups that participate in upland cultivation vary in size. While individual households sometimes cultivate upland farms, the most common unit for upland cultivation is a cluster of households that typically make up an extended family. This is especially true for the Shona people, who migrated from Zimbabwe and settled near *dambo* K (Shimada 2002): an extended family forms a cluster of households that cultivate upland fields as a group.

All members of the group share the work involved in cultivating the upland farm. All plots that belong to adult male members of the group are cultivated in the order of seniority (age). Figure 5 shows a schematic rotation order. If the wife/wives of a deceased head of the family are alive, their plots will be cultivated first[4].

The nature of this group farming system is ambivalent. Although it provides labor, machinery, and seeds to those who lack these commodities, it also distributes risks unequally among the group members. Fields cultivated early in the rainy season have a higher probability of a good harvest than do those that are seeded later. Therefore, senior members have a better chance of a good harvest than junior members. Of course, this probability varies year by year because of irregular rainfall patterns, but villagers know by experience that planting early is better than planting late. Thus, the bigger the group, the higher is the risk of a failed production for junior members. Active junior members often become frustrated by delayed planting, which is one reason why big groups are susceptible to being dissolved into smaller groups. However, as long as members feel that the advantages outweigh the drawbacks, they will continue to farm in groups.

[4] Ja and He in Figure 8 are two widows left behind by the former head of the household. They are the mothers of the current head of the household, Jo.

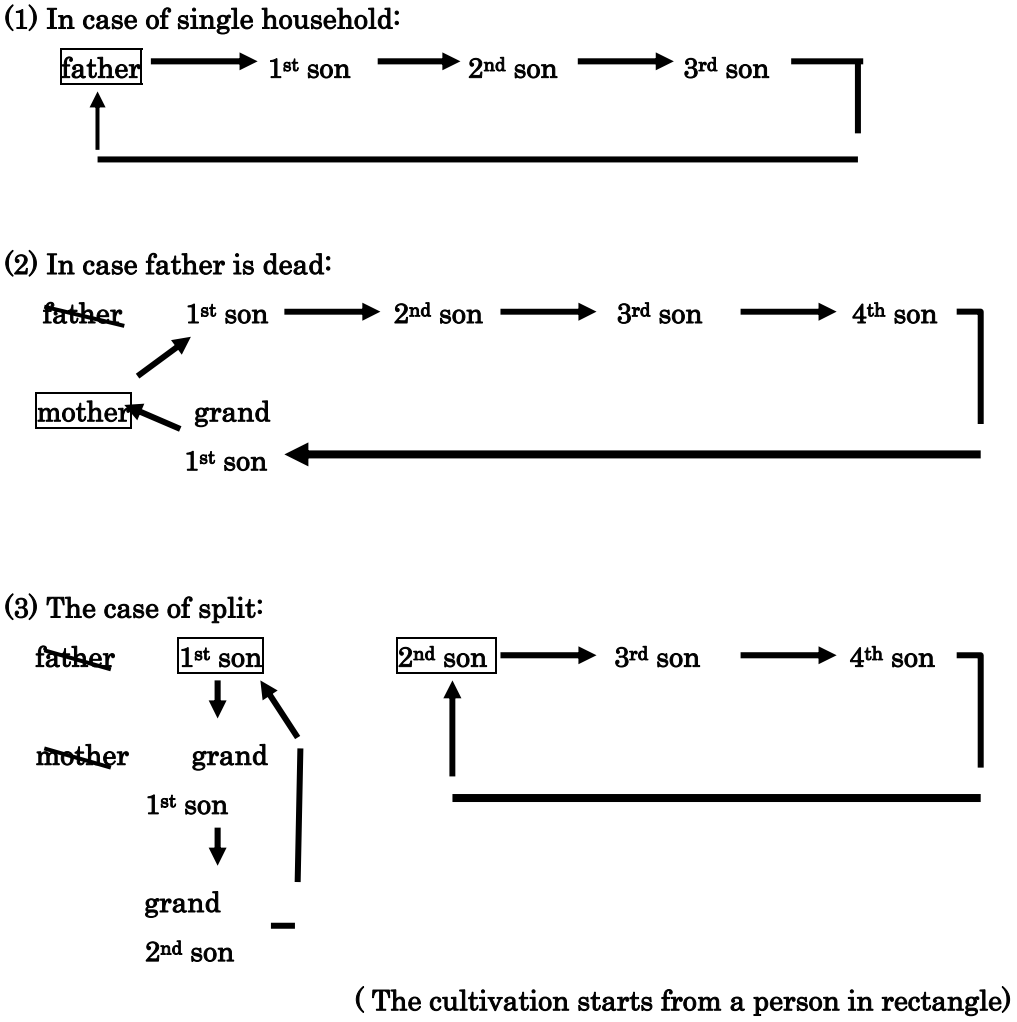

Fig. 5: Schematic order of cultivation in upland

Group dissolution usually follows the death of the head of a household or other senior member, although it may occur every time junior members demand it. The development of *dambo* cultivation, which is carried out by individual households, also influences the demand for dissolution.

VI. The importance of group cultivation and mutual help

Upland farming requires at least one plow and two mature cattle, as well as an adequate supply of maize seeds and, if possible, fertilizer. However, some farmers do not own these essentials. Figure 6 shows the number of cattle owned by each household in 1996, 1997, and 2000.

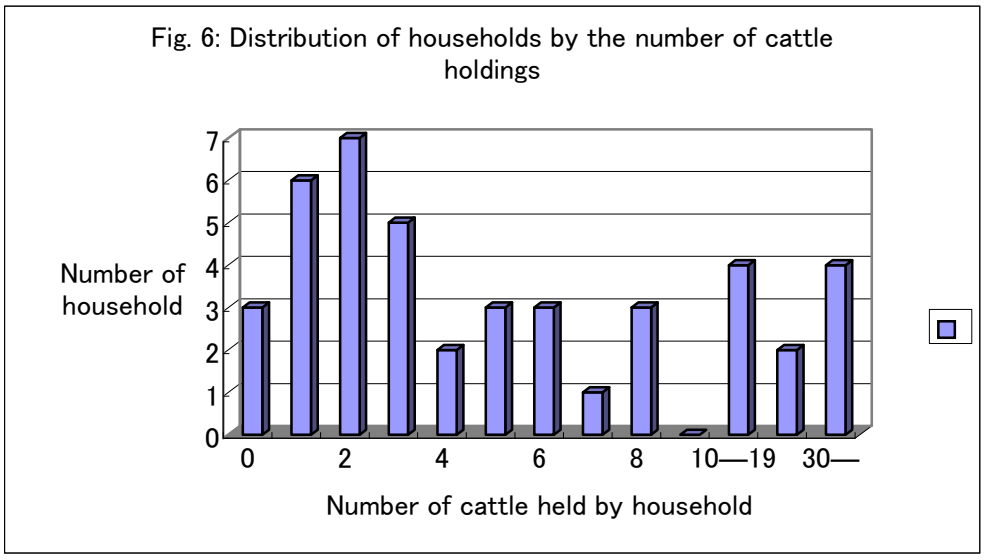

Fig. 6: Distribution of households by the number of cattle holdings
This shows the sum up of the results of study for fifteen households in 1996 and fourteen households in 1997 and 2000. In these three years, the study was conducted in August.

About 19% of households have fewer than two cattle and are therefore unable to cultivate their fields alone. At the time of the first rain, cattle for plowing are critical in upland cultivation, as the first planting must be initiated properly over a short period following the first rain.

In this respect, group cultivation functions as an important mutual help system. This system is particularly beneficial to widows, divorced women, and young couples who lack agricultural equipment and/or cattle. It also helps absent group members who have cattle and farmland in the village but who cannot return to the village in time for cultivation. In this system, plots of all members will be cultivated regardless of whether they are present at the time of cultivation. People who are ill also benefit from this system.

If a group owns more cattle and equipment than it requires, it will lend these commodities to other groups in need. Cattle and/or equipment are typically loaned in exchange for money or maize, and sometimes even for free (Table 2). Loans are based on good relationships among kin or friends. Table 3 shows such interchanges observed during the 2000/01 rainy season in xx families.

Table 2: Work without charge

Service given		Relations
Lend oxen and plow	8 days	to cousin
Lend oxen and a cart	9 days	to relative
Lend a ox	3 days	to friend
Lend a cart	4 days	to brother
Lend a farmland	for nursery	to friend
Childcare	n. a.	to friend
Lend a pumping machine	n. a.	to friend
Plowing	n. a.	to relative
Mutual work	3 days	to friend

(Interviewed for the year of 2000/2001)

Table 3: Contract work with payment

(Interviewed for the year of 2000/2001)

Contract work	goods received	Contract work	money received
Plowing (1 day)	maize(2 bags)	Plowing (1 day)	25,000K
Plowing (3 days)	maize(2 bags)	Plowing (2 days)	30,000K
Plowing (2 days)	maize(1 bag)	Plowing (45 yards)	45,000K
Plowing (3 days)	maize(1 bag)	Plowing (30 yards)	30,000K
Plowing (2 days)	maize(10 cans)	Plowing (50 yards)	50,000K
Plowing (2 days)	maize(10 cans)	Plowing (42 yards)	42,000K
Plowing (4 days)	maize(2 bag s)	Plowing (2 days)	n. a.
Plowing (3 days)	maize(1 bag)	Plowing (1 day)	n.a.
Plowing (2 days)	maize(1 bag)	Plowing (5 days)	n. a.
Plowing (2 days)	maize(1 bag)	Plowing (2 days)	n. a.
Plowing(2 days)	maize(1 bag)	Plowing (1 day)	n. a.
Plowing (piece work)	maize(2 bags)	Repairing	70,000K
Block layer	maize(2 bags)	Repairing	45,000K
Get an advance100,000K	maize(4 bags)	Repairing	n. a.
Plowing (1 day)	fertilizer(1 bag)	Lend a cart(half day)	1000K x 30
Weeding(1day)	fertilizer(1 bag)	Lend a cart(half day)	1000K x 30
Weeding(2 days)	fertilizer(1 bag)	Lend a cart(half day)	500K x 50
		Lent two oxen (half day)	n. a.
		Lend two oxen(half day)	n. a.

Payments listed in the table will be procured some time later. In most cases, payments are made after the maize has been harvested, although it is quite common for debtors to leave their debts for months or even over a year.

Table 4 illustrates the case of a debt that remained unpaid for more than one year. This debt was incurred when several villagers received meat from a farmer in 1997. The farmer did not coerce his debtors to pay back their debt, because he knew he could reclaim it any time he desperately needed it. At the basis of this transaction lay a good human relationship between lender and debtor. A lender can reserve the right of claim for more serious cases and will claim seed maize or money when he truly needs them. While such transactions or free exchanges do

not guarantee an equivalent return to the creditor, they do contribute to increasing access to resources.

Table 4: Debt unpaid more than one year;

Name of Debtor	Pledged money or maize to pay
Mrs. Mu.	6500K
Mrs. C.	6000K
Mrs. Mn.	5000K
Mrs. Shi.	5000K
Mrs. Z.	1500K
Mr. Ti, Z.	2500K
Mr. Chi.	2 bags of Maize
Mr. Shi.	4 bags of Maize
Mr. Mu	3 bags of Maize
Mr. Wa.	9 bags of Maize
Mr. Sha.	2 bags of Maize
Mr. Nk.	1 bag of Maize
Mr. Mus.	3000K

(Mr. Ps slaughtered an ox in August 1997. These are debt unpaid for the meat in August 1998)

K: Kwacha (1 US$ was equivalent to 1400K)

A bag of Maize was about 30,000K

VII. High death rates and their impact on group farming

The death of an active adult results in the loss of industrious and productive human capital. Hospital charges, funeral payments, and extra-funerary expenditures impose a financial burden on the surviving group members. In addition, deaths influence agricultural production by affecting the group farming system. As discussed earlier, group farming and the mutual help system play an indispensable role in upland farming, but this role has begun to change for several reasons. One of the most recent and most serious reasons is an unexpectedly high death rate.

Figure 7 shows an example of successive deaths in an extended family. Five households in village C belonged to extended family S. These five households formed a farming group, of which J.S. was the most senior male member and therefore head of the group. This is one of the most serious cases observed in the village. Seven adults and four children have died since 1998. The death of an adult has a very serious impact on agricultural production over the short and long term, and as far as the impact on agricultural production is concerned, the death of an adult

is more serious than the death of a child. Some examples from the extended family of J. S. follow.

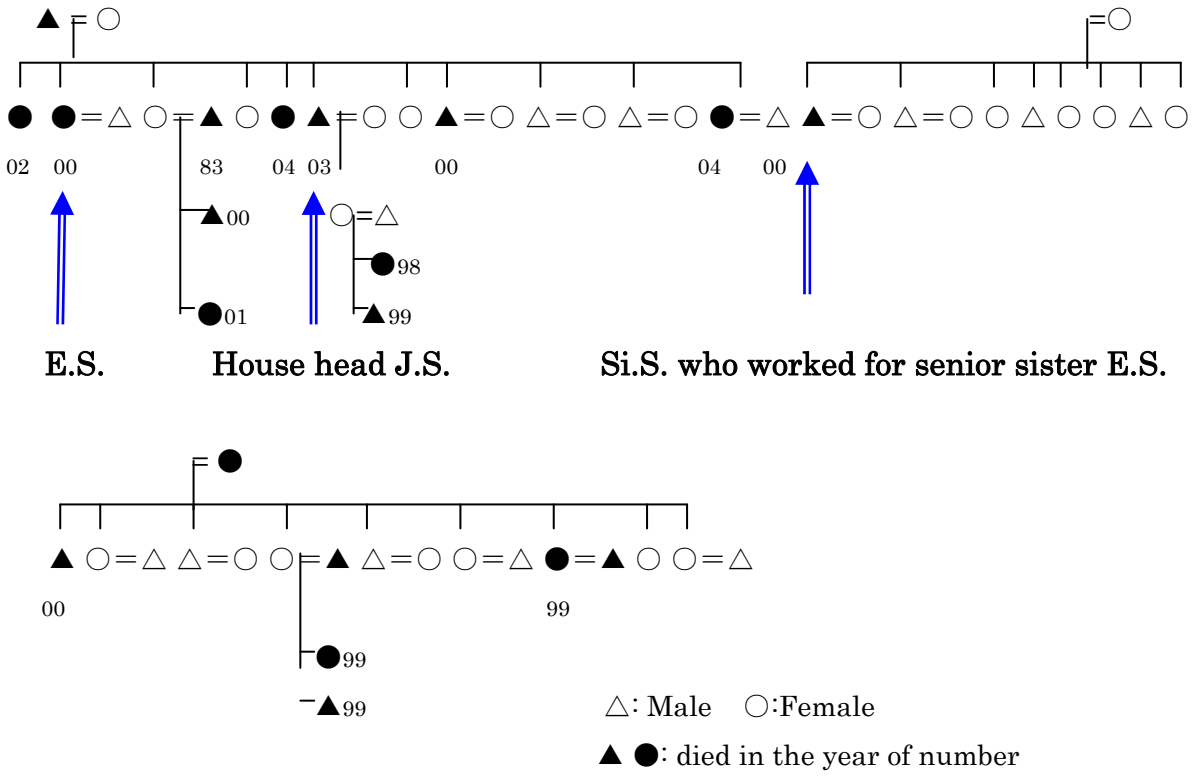

Fig. 7: Recent bereavement of family S

Case I: Death of the second wife of J.S. (November 1998)

J.S.'s second wife died after a short illness. On the occasion of her funeral, her brothers claimed some cattle and property, declaring that four cattle were overdue for the bride price. After long negotiations, they settled on cattle payments and allotment of property, and J.S. agreed to pay two cows and a calf. These negotiations continued for several weeks during the busiest time of the maize cultivating season. During his absence from the village, J.S. left his junior brother in full charge of group farming activities.

Case II: Death of the junior brother, Si .S.(May 1999)

Si,S. the junior brother of Jo, lived with their senior sister in village M, about 50 km from village C. Si.S. had been sent to help her farm after the death of her husband. Her husband had been a policeman who had helped family S on several occasions, e.g., he had settled disputes with another family and obtained detention releases.

Si.S. died after 18 days in a hospital, so Jo and his two young brothers went to village M to help harvest maize for their sister. They stayed there for over three weeks and harvested >200 90-kg bags of maize. The medical costs were two million Kwatcha (equivalent to U.S. $800 at the time). J.S. asked his sister to sell 85 bags of maize to make the payment, and he sold two of Si.S.'s cows to make up the difference.

He also slaughtered one cow for the funeral; thus, only one cow and one ox remained for the bereaved family. Si.S.'s wife returned to her father's house with her youngest baby. She took two sheep and all of her own property with her. J.S. took in the other four children; he and his junior brothers are now foster fathers.

During their long absence from village C, harvesting was left to the second senior brother and to J.S.'s children. However, the harvest was poor because of theft, which resulted from a lack of labor during the critical time.

Case III: The death of senior sister, E.S. (March 2000)

E.S.'s husband was an influential politician and very generous patron of extended family S. He contributed to shifting the village boundary to the east, towards the Forest Reserve.

This re-arrangement of the boundary lines secured land for the families around *dambo* K, which before 1981 marked the boundary between village C and the Forest Reserve.

E.S. had loaned J.S. a pickup truck and a flourmill to help extended family S, but her sons reclaimed them immediately after her death. They insisted that the truck and mill were generously on loan to family S but that the ownership had not been transferred to them. The dispute continued for over two months and prevented J.S. from harvesting his maize himself. J.S. asked his young brothers to help his children harvest the maize, but this repeated request angered the brothers. In this year, the large farming group of extended family S was divided into smaller groups based on each household. Since then, J.S. has cultivated his farmland with members of his own household.

Figure 8 shows the actual order of cultivation observed in extended family S, which made up the largest farming group in the village until the 1998/99 season. At that time, over four weeks were required to finish one cycle of cultivation. The group decreased in size during the 1999/2000 season and finally split into three groups in 2000/01. The case studies described above discuss the reasons for this dissolution. Junior members of the group were frustrated with having to wait for their turn to cultivate their own fields. To add to this, their personal losses imposed a heavy burden, both economically and socially. The big group was therefore perceived not as a help, but as a hindrance, and was subsequently dissolved.

(1) until 1997/98 rainy season: It took four weeks and two days for one cycle.
JaJaHeHeJoJo DaDaCrCrSiSi MuMuHaHaHoHo PaPaObObBrBr PaPa

(2) until 1999/2000 rainy season: It took two weeks and two days for one cycle.
JaJaHeHeJoJo DaDaCrCrSiSi MuMuJaJaHeHe JoJoDaDaCrCr SiSiMuMu

(3) The group was divided into three groups in 2000/01 rainy season:
(i) JoJoJoJaJaJa JoJoJoJaJaJa JoJoJoJoJoJo *JoJoJoJsBrPa*
(ii) DaDaDaDaDaDa (after second week, Da asked a friend farming by contract)
(iii) CrCrCrMuMuHa CrCrCrMuMuHa CrCrMuJo*CrCr CrCrCrCrCrCr*

1st cycle 2nd cycle 3rd cycle *4th cycle*

Fig. 8: Actual order of cultivation in the family S

The long and frequent absences of J.S. from the village also affected group farming. The head of an extended family who organized and made all group cultivation decisions became more occupied with non-agricultural issues, such as visiting the hospital, preparing and arranging funerals, and paying and collecting debts. During his absence, the second or the third senior male made decisions in lieu of the head of the family, but so many deaths, and such long absences on the part of the household head affected farming practices. His control over upland farming became weak and junior members who acted on his behalf became displeased with their position as only 'acting' heads of the household.

VIII. Conclusions and remarks

Successive deaths of family members have influenced upon agricultural production seriously. In addition to the direct and immediate impact of deaths, there are indirect and prolonged effects, such as to foster children, to pay off debts, to settle succession, and to re-organize group for farming.

The mutual help system that was devised to compensate for a lack of cattle, equipment, and labor was rendered dysfunctional by these prolonged effects. The mutual help system like large farming group has become unable to absorb the burdens created by the frequent deaths. Instead, the system functioned as a catalyst that transmitted vulnerability among members of the group.

This study implicates that the well functioned institutions in normal condition may increase vulnerability in case of abnormal situation instead of preventing it. This means that

factors operate to enhance vulnerability one time may act to reduce vulnerability in other time. The orbital process of increased vulnerability is complicated.

This is why we should be very careful to analyze the vulnerability and resilience of society. The hasten generalization of increased process of vulnerability should be avoided. Instead vulnerability and resilience of a society should be studied deliberately by understanding the particular geographical and historical settings.

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Consideration of Temporal / Spatial Resolutions in Environmental Analysis

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1. Introduction

Remote Sensing and Geographic Information System(GIS) are powerful tools for gathering , retrieving various kinds of spatial distributed informations and analyze an environmental conditions. Remote Sensing and GIS are tools not only for scientific research on how the world works, but also for technological applications in meeting human needs. The need between research and application is especially important to the emergent programs for monitoring the environmental and social consequence of global change.

The type of spatial information system required for regional to continental scale environmental analysis is huge volume (e.g., 103-106 megabyte) and may include fundamentally different kinds of data, for example, (a) multi-temporal and multi-resolution digital images acquired from one or more satellite and aircraft platforms; (b) digital maps of land surface variables such as soil, hydrography, and vegetation cover; (c) socioeconomic data (e.g., population density, zoning district) aggregated by political reporting units. Here, we consider the temporal / spatial resolutions in an environmental analysis.

2. Scaling of Earth Surface Phenomena

The earth surface phenomena appear homogeneous at one spatial scale but heterogeneous at another. The scaling properties of earth surface valuables should be known and should guide the collection, processing, and interpretation of remote sensing and GIS data. Scale dependence is especially significant in the context of GIS analysis. It seeks to reduce or to exploit relationships among geographical valuables, because those relationships change as the spatial scale changed. The scaling properties of many earth surface processes are not well known, because these properties are frequently site or region specific and also time-dependent. And it difficult to generalize from isolated studies. A key sequence of scale dependence is the presence of spatial covariability in most spatial dataset.

3. Measurement and sampling geographic phenomena

Extrapolation of point measurements and model estimates to large areas remains a major problem in geographic analysis, and continued research is needed to identify appropriate sampling and scaling strategies for sparse ground measurements, especially in the context of regional and global assessments. Interpolating point measurements to a surface creates variation that may or may not approximate the scaling properties of the actual surface.

The measurement scale of remote sensing data is relatively well specified compared to many geographic data, but may still be quite uncertain. Resolution depends instead on the complex

generalization process applied by the analyst. For this reason the effective scale of GIS applied data is sometimes described in terms of the minimum mapping unit (MMU), but the actual MMU may vary both within and between maps as a function of map classes, terrain type, and analyst.

The pixel size is generally taken to define the spatial resolution of remote sensing data, although the term image resolution has various meanings. However, the measurement scale is not fixed. Resolution varies not only as a function of instantaneous field of view (IFOV) and altitude, but also because of many other factors including the sensor point spread function, surface-sensor geometry, atmospheric conditions, and data processing such as image rectification or enhancement. The earth surface processes and phenomena exhibit characteristic scale dependencies, remote sensing data of multiple resolutions, either from multiple sensors or from degradation of high resolution imagery, can be used to study and exploit those dependencies for mapping and modeling.

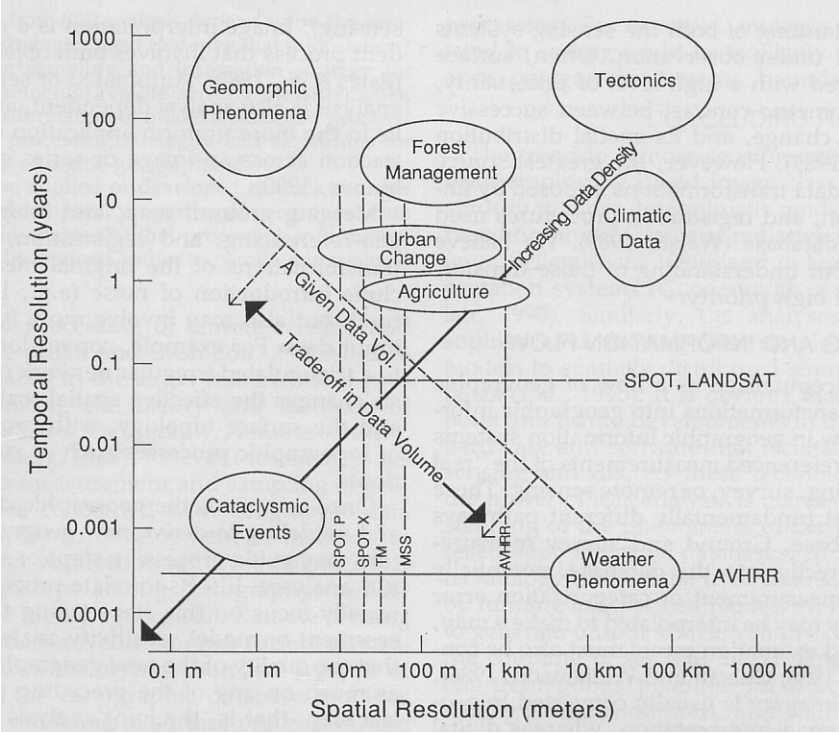

Fig. 1 Spatial and Temporal measurements scales for ground phenomena and remote sensing data.(Frank W. Davis, 1991)
Data Density decrease from lower left to upper light

Figure 1 is the spatial and temporal measurement scale for ground phenomena and remote sensing data. The data density depends jointly on spatial and temporal resolution, so that data density decrease from the lower left to upper right corners of this diagram. Increases in computing capacity have shifted the data volume threshold towards the lower left corner. There are still very real practical limits to the spatial and temporal domain of remote sensing

for regional and global analysis, and do the volume of data that can be effective archived, retrieved and analyzed. For global analysis, practical scales are still far more coarse than the measurement scales of many kinds of biophysical data. A challenge in combining remote sensing and GIS for Earth science studies is the proper nesting of observations at mulyiple space and time scale in order to link short-term, fine scale measurements and process models to long-term, broad scale measurement and modeling efforts.

4. Monitoring and Change Detection

Although satellite remote sensing has been used for monitoring earth surface processes through time, there has been remarkably little progress in quantitative spatiotemporal analysis of multi-temporal imagery for land surface analysis. There is a pressing need for such research applied to sensors with low spatial resolution and short repeat intervals as part of efforts to study global ecological changes.

There are many uncertainties in detecting change using multi-temporal satellite data. The ability to detect changes in a surface identified over time with remote sensing depends on the spatial, spectral, radiometric and temporal properties of sensor system. High frequency variation in solar, atmospheric and surface conditions during scene acquisition contribute noise to the analysis.

5. Thematic Information Extraction

The sensor systems and spatial resolutions useful for discriminating vegetation from a global to an in site perspective are summarized in Fig.2. This suggests that the level of detail in the desired classification system dictates the spatial resolution of remote sensing data. Spectral resolution is also an important consideration. However it is not as critical a parameter as spatial resolution since most of sensor systems record energy in approximately the same visible and near-infrared portions of the electromagnetic spectrum

The Level I is the global scale. Its typical satellite remote sensing data is NOAA/AVHRR with 1.1km resolution.

The Level II is second spatial level. It is continental. Used satellite data spatial resolution is from 80m to 1.1km. NOAA/AVHRR and Landsat MSS are typical sensors.

The Level III is Biome with 30m to 80m resolution. Landsat TM and MSS are the sensors.

The Level IV corresponds to the region scale with 3m to 30m resolution. Landsat TM and also IKONOS Multi-spectral as high resolution satellite data.

The Level V is Plot. This scale corresponds to high resolution satellite data at this moment. It is IKONOS or Quick Bird.

The Level VI is the most detailed spatial scale. It is In Site sample Site. At this level, all of phenomena can observed by direct surface measurements and observations

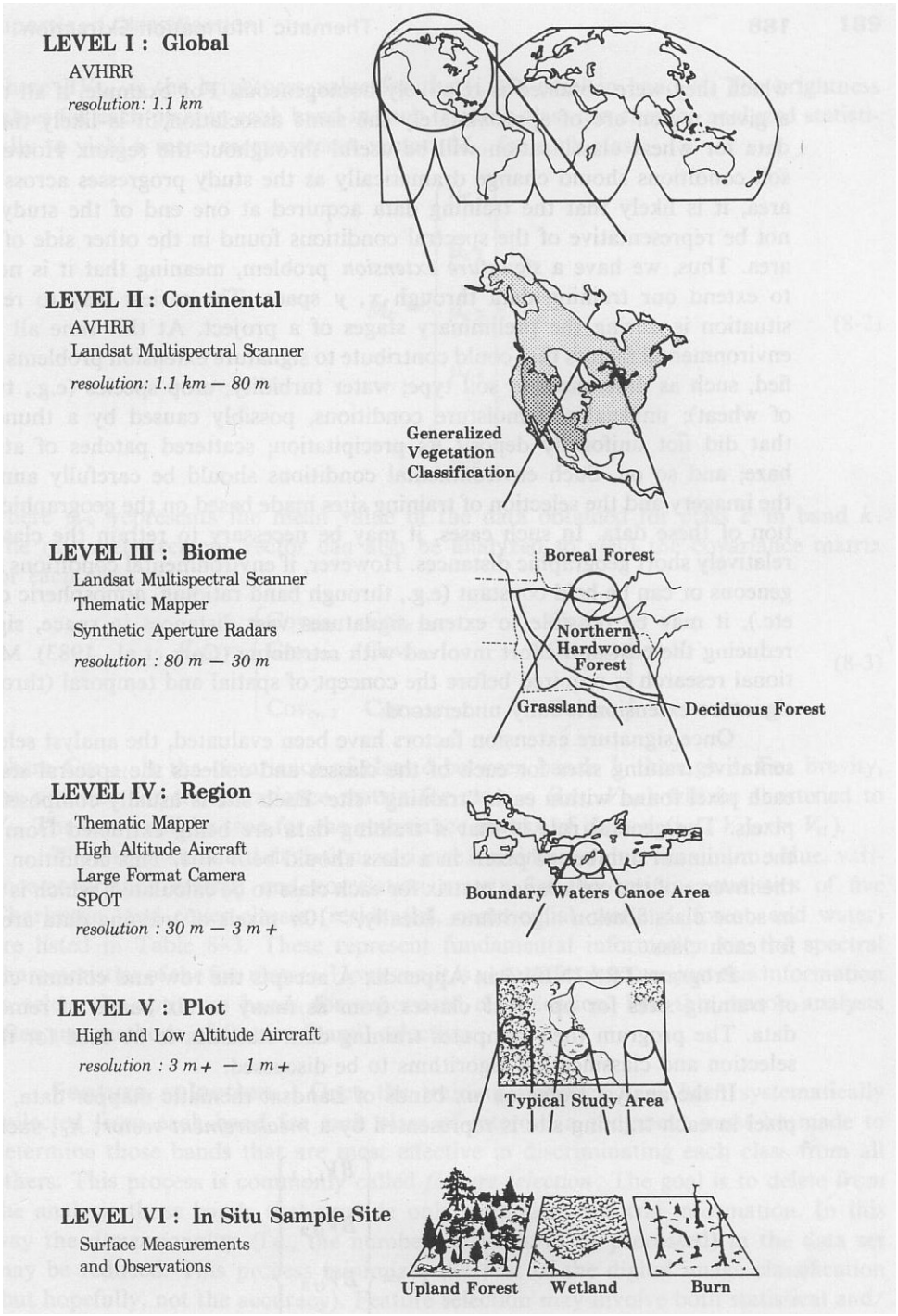

Fig. 2 Relationship between the Level of detail required and the Spatial Resolution of Various Remote Sensing Systems for Vegetation Inventories.
(From NASA, 1983;Botkin et al.,1984)

Climate Changes and their Effects on Natural Disaster in Zambia

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1. Introduction

Some part of Zambia is located in Semi-Arid Tropics (SAT) where most of farmers live by agriculture depending on meteoric water and the farmers' livelihood tend to be affected by droughts thouguh some part of Zambia effort to manage water demand for irrigated agriculture, industry and hydropower (e.g. the Kafue flats [Herbertson and Tate, 2001]). Sakaida [1993] analyzed relationship between rainfall changes and maize production in Zambia using annual rainfall data of 23 stations and concluded that the effect of annual rainfall change on maize production was evident in the Southern province.

In Zambia located in SAT, to investigate resilience of the farmers against changes in ecological system and human activities, analysis and monitor of meteorological data are essential. This report aims to describe preliminary research results in this fiscal year and future possible research plan in terms of meteorology and related fields.

2. Preliminary field research in Zambia

During the field trip to Zambia in August 2005, we visited Meteorological Department, Ministry of Communications and Transport (Fig. 1) at Lusaka and interviewed an acting chief meteorologist, Forecasting and Research Division. As for meteorological data they operate 36 meteorological monitoring sites for meteorological elements such as temperature, precipitation, evaporation, air pressure, sunshine, and cloud cover. Some sites have been operated since 1950. We also visited two meteorological sites at Choma and Lusaka City Airport (Fig. 2 and 3).

Fig. 1 Meteorological Department, Zambia.

Otherwise official meteorological sites operated by Meteorological Department there are some voluntary stations at where mainly only rainfall data was recorded by villegers. These rainfall data are reported to Meteorological Department but are not merged with official data.

Fig. 2 Meteorological site at Lusaka City Airport.

Fig. 3. Meteorological site at Choma.

These voluntary-collected data are recorded only on papers as seen in Fig. 4.

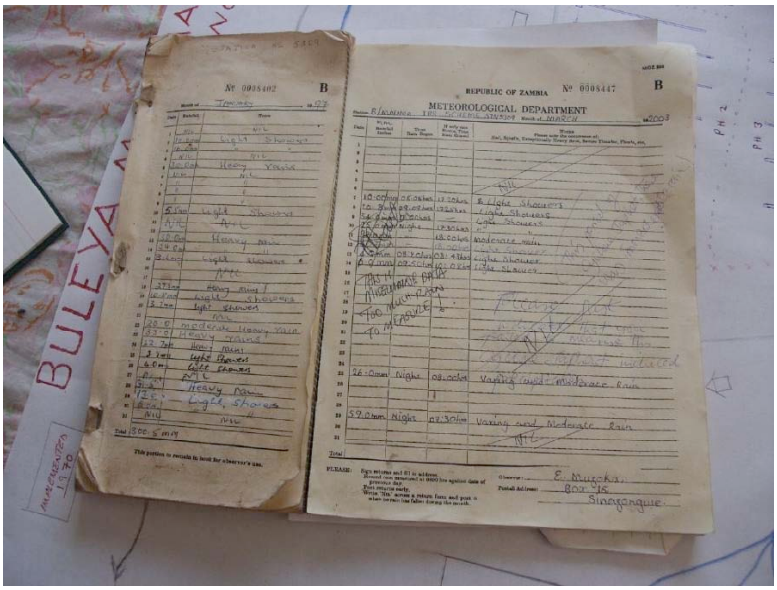

Fig. 4 Voluntary rainfall record at Sinamalima

Ministry of Communications and Transport reported that the first half (Oct-Nov-Dec) of the 2004/2005 growing season, rainfall performance was normal or above over most of areas in Zambia except for the western part but during the second half (Jan-Feb-Mar) of this rainy season they have not much rain as expected in the southern half of Zambia [The Director of Meteorology, 2005]. Farmers in the southern region also said that the 2004/2005 drought was heavy which was comparable to a big drought in 1991/1992.

As the first stage of our project we obtained annual rainfall data from 1993 to 2004 at 9 official meteorological sites as listed in Table 1 and Fig. 5. Figure 6 shows obtained annual

Table 1 List of meteorological monitoring sites at which we obtained rainfall data.

Site Code	Latitude [d m]	Longitude [d m]	Elevation [m]	Site Name
CHIPAT01	13 33	32 35	1032	CHIPATA MET
CHOMA001	16 51	27 04	1267	CHOMA MET
KAFUE001	15 46	27 55	987	KAFUE POLDER
LIVING01	17 49	25 49	986	LIVINGSTONE MET
LUSAKA01	15 25	28 19	1252	LUSAKA CITY AIRPORT
LUSAKA02	15 19	28 27	1154	LUSAKA INT. AIRPORT
MAGOYE01	16 08	27 38	1018	MAGOYE AGROMET
MTMAKU01	15 33	28 15	1213	MT. MAKULU AGROMET

rainfall from 1993 to 2004. As seen in Fig. 6 precipitation is highly variable at each sites. Precipitations in 1994-1995 and 1998 are relatively low than the other year, but severe damage to agriculture was not reported. We are planning to get and analyze monthly or more precise meteorological data at each sites.

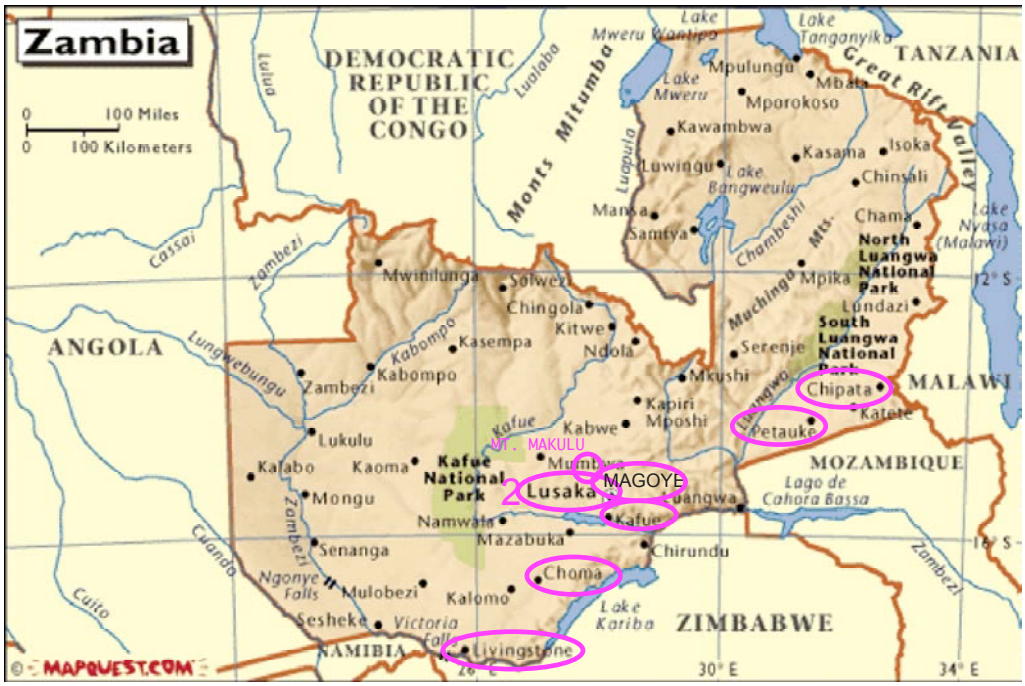

Fig. 5. Locations of the sites. (A Map is referred from http://www.mapquest.com .)

3. Future research plan

To estimate effects of variable climatic factors especially rainfall and impacts human activities on farming, measurement of plot-level (inside a village) rainfalls may be important. We will install small rain gauges as well as devices to measure basic meteorological parameters in some villages. Voluntary-recorded rainfall data and interviews with persons who record data might be helpful for village level analysis.

For a district level analysis, official data stored by Meteorological Department will be collected. Since a climate in Zambia is influenced by the Inter-Tropical Convergence Zone (ITCZ), the southeast wind over the Indian Ocean an analysis of global meteorological data set is helpful. In terms of district and continental scales RIHN has meteorological data set by ECMWF (European Centre for Medium-Range Weather Forcast). This data set contains operational and re-analysis data for major meteorological parameters for whole globe in resolution of 2.5˚ x 2.5˚, latitude and longitude respectively. More precise resolution data of 0.5˚ x 0.5˚ will be available from ECMWF in the next stage of this project. Analysis of

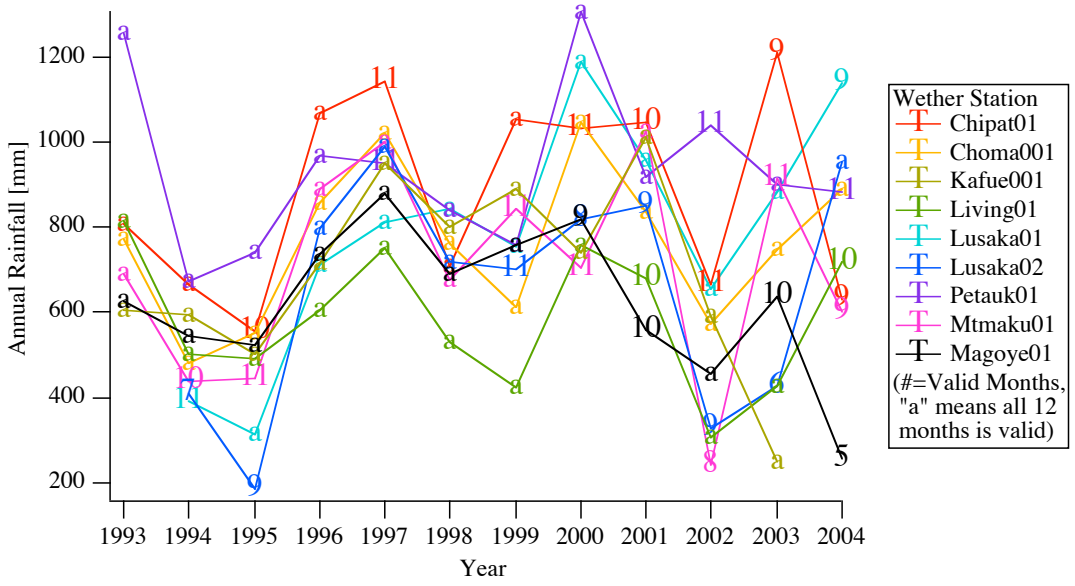

Fig. 6 Annual rainfall data from 1993 to 2004 at 9 official meteorological sites in Zambia

these data sets in a viewpoint of climate change in Zambia will be useful to resolve a relationship global climate change and its effect on Zambia. Model simulation by running a regional meteorological model might be inside the scope of our research to investigate meteorological condition in Zambia.

4. Conclusion

Through official and unofficial (interviews with farmers) information in Zambia, life of farmers in Southern and Eastern Provinces is affected by drought in 2004/2005 year which was comparable to 1991/1992 drought. By analysis of meteorological data in these two big drought years and a normal year including and monitoring the present whether we will be able to get some global and/or regional patterns of climate change of drought year and to integrate the results with the other results of this research project may results in finding what are the conditions of the droughts and farmers' resilience against variable environment.

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Abstract of Resilience Seminar in FY2005

The 7th Resilience Seminar

Date and Time: 28 April 2005, 15:30-17:00
Place: RIHN Meeting Room

Title: Experiences of the participatory community-support activities toward co-existence between ecosystems conservation and human welfare – a case of mountain village in Tanzania-

Speaker: Ueru TANAKA, Laboratory of Terrestrial Ecosystems Management, Graduate School of Global Environmental Studies, Kyoto University

[Abstract] Ecosystems and land resources of the mountains and highlands, one of the typical landscapes in Esat Africa, have been rapidly degraded under ever increasing land use pressure. As a serious reality, the daily activities by rural communities for foods and household income are major cause of degradation. It is, therefore, urgently necessary to develop some activity options that enable to meet the needs and to solve the problems at the same time, as well as to empower the rural communities. The presentation introduces some experiences and findings in the rural development project in the Uluguru Mountains, eastern Tanzania, particularly focusing on the potentialities of people's participation, ways to utilize knowledge and techniques of local husbandry systems, and roles of outsider's commitment. Some examples of the activity options include "reforestation without planting trees through bee-keeping", "reappraisal of indigenous shifting cultivation as an inherent food security system" and "indirect reduction of labor-burden fro! m slush-and-burn cultivation and creation of income sources through incorporation of vanilla as a component of indigenous home-garden agroforestry system".

The 8th Resilience Seminar

Date and Time: 10 June 2005, 11:00-12:15
Place: RIHN Meeting Room

Title: Recent progress in lake ecosystem resilience -an overview
Speaker: Shigeo Yachi, RIHN

[Abstract] A review of recent progress in lake ecosystem resilience researches was presented. After summarizing changes in ecosystem view in ecology, the meaning of "resilience" in

ecology was classified. Then, an integrative regime shift research in lake ecosystems using experiment, comparison and simulation by Carpenter et al. was focused on in the talk. (Kathryn L. Cottingham and Stephen R. Carpenter "Predictive Indices of Ecosystem Resilience in Models of North Temperate Lakes" Ecology, 75(7), 1994, pp.2127-2138.)

The 9th Resilience Seminar

Date and Time: 21 July 2005, 15:00-17:15
Place: RIHN Meeting Room

15:00-16:00
Title : The change of land use in the social dynamics of eastern Zambia-The creation of new fields by Chewa farmer -
Speaker : Ryuta Yoshikawa, Graduate School of Asian and African Area Studies, Kyoto University

[Abstract] Chewa farmer living in eastern Zambia have experienced big changes of agricultural policy since 1980s. The purpose of this presentation is to clarify how the people have coped with social economic changes. I focus on the changes of crops and land use, in particular. Moreover, I examine the relevancy of correspondence to the situation and the change of habitation.

16:00-17:00
Title: Rural Response to the fluctuations of international coffee price: Market liberalization and 'Coffee Crisis' of Ethiopia in the 1990s.
Speaker: Keiichiro Matsumura, Graduate School of Human and Environmental Studies, Kyoto University

[Abstract] In the early 1990s, Ethiopian government introduced the market economy to agricultural products including coffee, which was formerly under the public price control. After the liberalization of market, coffee-growing areas suffered from widely fluctuated coffee price. This presentation examined the drastic transition of rural area in the 1990s, especially focusing on the resilience of land use practice and subsistence strategy of local farmers.

17:00-17:15 General Discussion

The 10th Resilience Seminar

Date and Time: 21 October 2005, 15:00-17:30
Place: RIHN Meeting Room

Title: Reorientation of the concept of sustainable development: an ecological resilience approach
Speaker: Satoshi Kojima, Institute for Global Environmental Strategies (IGES)

[Abstract] Since the publication of the Brundtland Report in 1987, the concept of sustainable development (SD) has been acclaimed as a common orientation of the global community in the policy arena at the global level as well as at other levels. Correspondingly vast amount of debates/studies about this concept has been accumulated, but they could not have established unanimous consensus on what it really means and what actions are required to achieve it. In this presentation it is proposed to define the objective of SD as "to eradicate poverty of the present generation without violating sustainability constraint", in which sustainability constraint is defined as to maintain resilience of ecosystems underpinning life-support systems. As an attempt to apply the proposed SD concept to policy analysis, a case study of Moroccan water issues is presented. The latest trends of ecological economics, as a discipline of sustainable development, are also briefly introduced.

The 11th Resilience Seminar

Date and Time: 25 November 2005, 15:00-17:30
Place: RIHN Meeting Room

15:00-16:00
Title: Local meteorological observation from 2001 to 2004 in Mali, West Africa
Speaker: Hiromitsu Kanno, Laboratory of Agricultural Meteorology, National Agricultural Research Center for Tohoku Region

[Abstract] The project group on "development of food crop production systems with reduced risk through advanced weather modeling for West Africa (JIRCAS)" has observed local meteorology in southern part of Mali from 2001 to 2004. The two villages--Niessoumana and Deou--were selected to the observation sites. A meteorological observation robot and fifteen rain gauges were arranged in each village. Main robot observes temperature, relative humidity, wind direction, wind speed, air pressure and precipitation. Data are automatically stored in CAMPBELL data logger, which works by battery and it's charged by solar-panel power

generation. Data-acquisition time-interval is ten minutes. Rain gauges are composed by sensors and small data loggers. The data loggers connected with rain-sensor memorize the precipitation-event-time per 0.1 mm, then we can calculate precipitation amount in any time-intervals.

As the results of local meteorological observation, we got the following results. 1. Local precipitation data show the wave-like distribution pattern in each village. 2. There are two peaks of precipitation amount--in the morning and evening. 3. There are some stages in a rainy season. 4. Meteorological elements indicate characteristic seasonal variations. Additionally, we found the seasonal movement of precipitation area from north to south in the southern part of Mali by using the historical rain data, and seasonal variations of air-mass structures by using upper meteorological data.

On the other hands, we had some troubles during our investigation, e.g. about the duties on our meteorological equipments brought from Japan, the damages of rain gauge's cable bit by termites and cattle, and the data-logger stops of unknown origin. We think that the information about troubles are also useful for other project researches in Africa. At last, we would like to introduce about climate and agriculture in northern part of Japan and to compare with those of West Africa.

16:00-17:00

Title: How Do Farmers Cope with Plot-Specific Rainfall Variation?: Empirical Evidence form Mali, West Africa

Speaker: Takeshi Sakurai, Policy Research Institute, Ministry of Agriculture, Forestry and Fisheries

[Abstract] In the JIRCAS's research project "Development of Food Crop Production Systems with Reduced Risk through Advanced Weather Modeling for West Africa," we conducted household survey and local weather monitoring in two villages located in southwestern Mail from 2001 to 2003. Based on the plot-level rainfall measured by rain gauges installed in fifteen different locations in each village, it is confirmed that farmers pay self-insurance premium based on the expected plot specific rainfall variation of one's own plot and that farmers who have experienced a lower level of rainfall than expected compensate *ex post* the income shortfall from other sources. Those findings imply that spatial rainfall variation even in a small area like a village is very large and that farmers' behavior to cope with the rainfall variation is also diverse accordingly. That is, "drought" defined at a regional level may not reflect correctly the situation of economic welfare of each household.

17:00-17:30 General Discussion

FY2005 1-3FS Project Research Activity Overview												
FY 2005	April	May	June	July	August	September	October	November	December	January	February	March
FS Seminar	13:00-17:00		9:30-12:30	13:00-17:15			11:00-17:30	13:00-17:30	13:00-17:00			
and Meeting	28-Apr		10-Jun	21-Jul			21-Oct	25-Nov	9-Dec			
(Resilience Seminar)	(7th Seminar)		(8th Seminar)	(9th Seminar)			(10th Seminar	(11th Seminar)				
Field Trip					Zambia Field Trip							
FS Project Report										FS Report Publication		
PR Project Proposal									PR Proposal			
FS Related Meetings	FS Hearing					(FS Hearing)	FS Study Group		RIHN Project Presentation			Evaluation
	4-Apr					21-Sep		4-Nov	14-Dec			Committee
	RIHN							RIHN	Coop Inn Kyoto			Hearing
												2-3 March
RIHN Events							Pre-Symposium		FS Study Group	PR Budget	Kamigamo	RIHN
							Nov. 18-20		3-Dec		transfer	
							Palulu Plaza		RIHN		Feb. 11-15	
Field Trip Schedule												
					Zambia		Bonn: IHDP	Zambia				
Umetsu					Aug. 1-13		Oct. 9-13	Nov. 1-17		(India)		
								Zambia				
Sakurai								Nov. 1-17				
					Zambia							
Saeki					Aug. 1-13							
								Zambia				
Shimada								Nov.11-Dec.1				
							Zambia					
Shinjo							Oct.26-Nov.1					
							Zambia					
Tanaka							Oct.30-Nov.25					
							Zambia					
Miyazaki							Oct.26-Nov.17					
					Zambia							
Yoshimura					Aug. 1-13							
										India		
Kume										Jan 16-22		

はじめに

地球研平成１７年度フィージビリティ（FS）研究「社会・生態システムの脆弱性とレジリアンス」はインキュベーション研究「貧困と環境資源管理―環境変動に対する人間活動の適応力に関する研究」として平成１５年度にスタートした。プロジェクトの名称はその後変更されたものの当初からのプロジェクトの目的は変わっていない。発展途上国の農村で環境資源に生活基盤を依存しながら暮らす人々の人間の安全保障を高めるために何らかの貢献ができる研究プロジェクトを創出したいと考える。

平成１７年度はプロジェクトメンバーがザンビアへ赴き、農民、大学関係者、政府機関スタッフ等から情報収集を行った。ザンビアの 2004/5 年の雨期は 1991/2 年以来の旱魃となり、東部州と南部州では主食であるメイズの生産が８－９割打撃を受けた。農民は食糧ストックが底をつきながら、次の収穫までの食糧確保に可能な限りの対策を講じていた。レジリアンス（回復能力）の概念はこの様に途上国農村の食糧安全保障のみではなく、また先進国にとっても重要な概念であることを、今年は自然災害によって大都市の機能が麻痺したアメリカ南部のケースを目の当たりにして知ることができた。

本プロジェクトは今年度 FS の段階を終え、次の段階へ移ろうとしている。1-3FS メンバーの方々にはプロジェクト申請書を完成させるために長い間ご協力をいただき感謝したい。また地球研の所長、主幹、管理部のスタッフの方々をはじめ、研究部スタッフ、P1-1 メンバーの方々にこの様な新しいプロジェクトを実現可能にするためにご支援いただいたことを感謝申しあげる。

平成１８年２月

梅津　千恵子
1- 3FS プロジェクト・リーダー
総合地球環境学研究所

P1－3FS　社会・生態システムの脆弱性とレジリアンス

プロジェクトリーダー：　梅津　千恵子　　略称：　レジリアンス・プロジェクト
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

1. 研究の目的と内容

1.1 研究の目的

A. 研究の背景と目的

貧困と環境破壊の悪循環は森林破壊，砂漠化などの「地球環境問題」の主要な原因である。そのもっとも顕著な例が，世界の貧困人口の大部分が集中するサブサハラ・アフリカや南アジアの半乾燥熱帯であろう。そこでは，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。この「地球環境問題」を解決するためには，人間社会および生態系が環境変動の影響から速やかに復元すること（レジリアンス）が鍵となる。そこで，本プロジェクトでは社会と生態を一つのシステムとしてとらえ，そのレジリアンスについて半乾燥熱帯を対象に実証的な研究を行う。

今まで環境資源に生業を依存する人々の脆弱性とレジリアンスについてはあまり注目されてこなかった。特に環境資源に依存する途上国の農民や牧畜民にとって，人口増加や地域コミュニティの崩壊による社会経済システムの回復力の損失は非常にクリティカルな問題である。このプロジェクトの目的は環境変動の中での人間活動を社会生態システムのレジリアンスという観点から捉えることである。よって地域的環境変動が社会生態システムへ与える影響や，社会生態システムがショックから回復するメカニズムを明らかにする。またさまざまなケーススタディから，世帯やコミュニティが持つレジリアンスの容量を規定する要因や，制度がレジリアンスに果たす役割について考える。社会・生態システムの脆弱性を規定する要因を解明することによって，途上国において人間の安全保障を高める方策を提示することが可能となる。(図 1)

レジリアンス（回復能力）の概念は C.S. Holling (1973)の重要な論文「生態システムのレジリアンスと安定性」が発表されて以来，長い間生態学者の間で議論されてきた。工学的レジリアンスは攪乱以前の初期均衡に戻る回復時間として定義された。この単一均衡の概念は，その後，非線形，複数均衡，レジームシフトの概念を取り込み，攪乱に耐えうる容量を強調した生態的レジリアンスの概念として拡張された。近年，これら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なされている (Levin et al. (1998); Levin (1999); Berkes, Fikret & Folke eds. (1998); Berkes, Colding & Folke eds. (2003))。

これらの発展は１９８０年代に創設されたエコロジー経済学の出現と歩みを共にした。この新しい学問領域の重要なアジェンダは社会経済学的研究と生態学的研究をリンクさせることであった。しかし，エコロジー経済学は主に先進諸国で発展したため，貧困や環境

荒廃などの重要な開発問題にはあまり注目しなかった。同時に既存の開発経済学は人間の経済活動の基盤となるエコロジーの問題にはほとんど関心を示さなかった。途上国の資源荒廃等の緊急の課題を解決し，人間の安全保障を高めるために社会生態システムのレジリアンスの概念を貧困削減等の開発問題に応用することが急務となっている。

半乾燥熱帯（semi-arid tropics: SAT)では，人々の生業は環境変動に対して脆弱である。半乾燥熱帯（図２）は，絶対貧困層の絶対数および人口全体に占める割合がここしばらくは大きいままであると予想されるサブサハラ・アフリカや南アジア地域が含まれる。この地域に住む多くの人々は脆弱な天水農業システムに依存している。食料安全保障の増加，生業のレジリアンス，貧困削減がこの地域の緊急の課題となっている。２００５年３月に開催された環境開発大臣会議でも特にサブサハラ・アフリカ地域での脆弱な人間環境に対する地球温暖化の影響調査の必要性が強調された。そこで，本プロジェクトでは国際社会で重要な「地球環境問題」と認識されている半乾燥熱帯地域での環境変動の影響と人間社会のレジリアンスについて考察する。

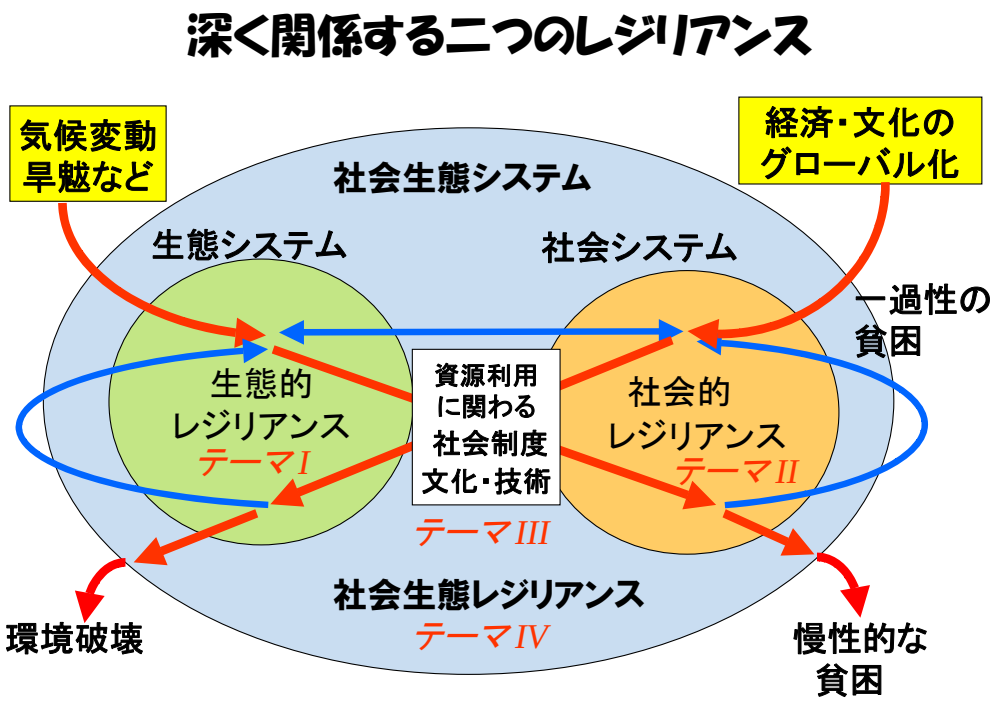


図１．社会生態システムのレジリアンスと４つのテーマ

B. 研究の目的

この研究の目的は以下の通りである:

1. 半乾燥熱帯地域における人間活動の脆弱性とレジリアンスを通して, 環境変動の影響を考える。
2. 社会・生態システム及び影響とショックからの回復を規定する要因を解明する
3. 世帯とコミュニティの回復能力を形成する要因やレジリアンスに果たす制度の役割を分析する。
4. よって社会・生態システムのレジリアンスを規定する要因を解明し，半乾燥熱帯地域での環境変動に対するレジリアンスを高める方策を提案する。

B. プロジェクトの最終成果

社会・生態システムの脆弱性に起因する環境破壊を「地球環境問題」であり，それに対するレジリアンスを高める方策を考えることが「地球環境問題」を解決するための第一の目標であると考える。研究プロジェクトの期間中，データ収集，観察と分析によって，レジリアンスの鍵となる指標を探し，それらの指標を用いて望ましい社会制度，生態システムの資源管理手法についてのオプションを提示する。

1.2 研究体制と研究の内容・方法

A. 研究組織

研究目的遂行のため４つのテーマに焦点を当てる。４つのテーマが互いにリンクしながら社会・生態システムの統合的なレジリアンス評価を行う。研究組織はテーマごとに各テーマリーダーの総括のもと，サブプログラムに必要な人材を配置する。従来型の専門分野によるグループ分けではなく，研究テーマによる研究組織を作り，また研究者がテーマに重複参加することによって多分野の研究者による柔軟な研究組織と研究目的の遂行を目指している。

テーマ I: 環境変動下での生態レジリアンスと人間活動
テーマII: 変動する環境への家計とコミュニティの反応
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
テーマ IV: 社会-生態システムに対する統合解析

テーマ I と II では地域的もしくは村落単位の分析を行い, その研究をテーマ III と IV で時間と空間スケールでの分析を広域に拡張して行う。その研究内容実施に適した土壌学，農学，開発経済学，資源経済学，人類学，環境地理学，気候学，リモートセンシング等必要な人材の確保を行った。時間スケールは社会的，自然環境が急速に変化した１９６０年代から現代までとする（図４）。

研究協力機関:

ザンビア

ザンビア大学社会経済研究所

ザンビア中央統計局

ザンビア農業組合省マウントマクル中央研究所

ザンビア交通通信省気象局

ザンビア国土資源省測量局

アメリカ援助庁・ミシガン大学・食料安全保障研究プロジェクト

インド

タミルナドゥ農業大学水資源技術センター

ブルキナファソ

ワガドグ大学

B. 調査対象地域

調査対象地域は半乾燥熱帯（semi-arid tropics: SAT）に位置する国々である。 半乾燥熱帯は予測困難な天候，長い乾季，突発的な降雨，肥沃度の低い土壌などの特徴を持っている(Barghouti, 1999)。この地域は世界人口の６分の１が住み，そのうちの２分の１は一日１ドル以下で暮らす絶対貧困層である。半乾燥熱帯の人口の多くは天水農業地域に住み，彼らの生業は脆弱で乏しい自然資源に依存している。半乾燥熱帯でのターゲットとなる調査地域は，南部アフリカ地域（ザンビア，ジンバブエ），西アフリカ地域（ブルキナファソ，ニジェール），南アジア（インド）等である。特にザンビアの農業地域に焦点を当て，集中したフィールド調査を実施する。ザンビアでは，旱魃常習地帯である南部，東部及び中央州を調査する。これらの調査対象地域は農業生態ゾーンの I と IIa に属し，降雨量はそれぞれ 800mm 以下と 800mm-1000mm の間である（図２，図３）。

C. 研究内容と方法

本プロジェクトでは社会・経済システムの計量的，定性的なレジリアンス評価を行う。社会・生態システムのレジリアンスは，i) 自然と社会のシステムがショックを許容できる容量，ii) ショックが発生したときの対処メカニズム，によって形成される。これらの容量と対処メカニズムは制度的変化等の外的な社会・経済的環境によって影響を受ける。本プロジェクトでは４つのテーマを設定する。テーマ１では生態レジリアンスを人間活動の影響を通して考察する。テーマ２では世帯とコミュニティのレジリアンスを生態条件から分析する。テーマ３ではレジリアンスを歴史的，制度的観点から捉える。テーマ４では前述した３テーマを統合し，社会・生態レジリアンスの評価を広域で行う。

図２．半乾燥熱帯地域と調査対象地域

図３．ザンビアの農業生態ゾーン

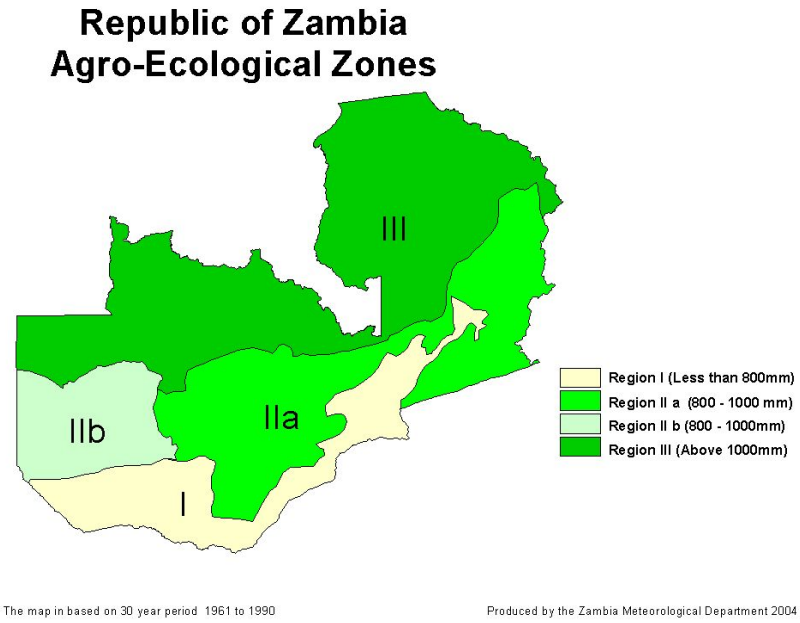
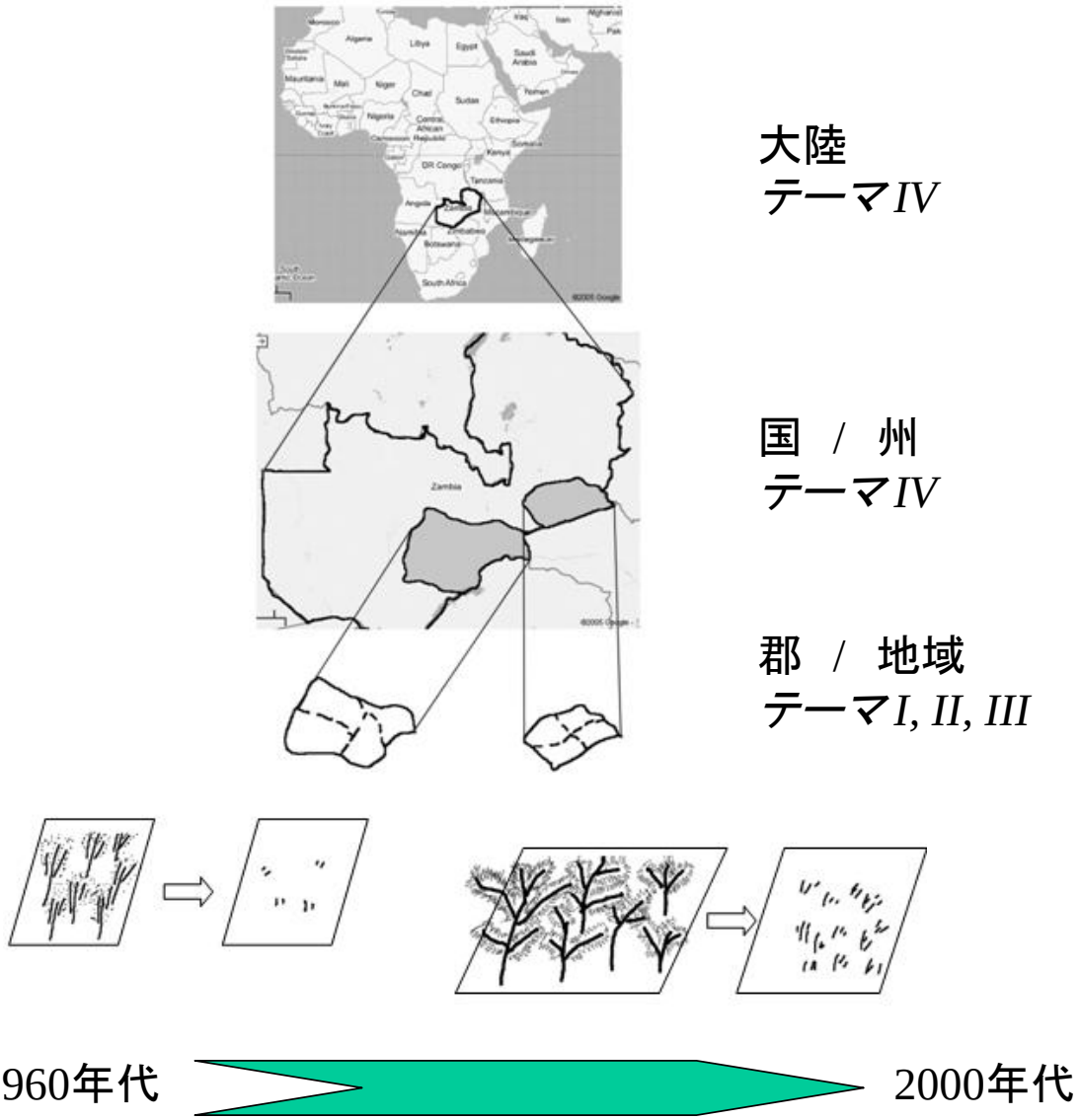


図４．分析のスケール



テーマⅠ：環境変動下での生態レジリアンスと人間活動 (テーマリーダー: 真常仁志)

生態レジリアンスとは，生態系が人間に対して持続的にサービスを提供する能力と定義できる。この意味において，耕作，放牧，薪炭材の伐採のような人間活動が，生態レジリアンスに負の影響を与え，結果として土地劣化が引き起こされると考えられている。しかし，人間活動と生態系との関係の非線型性や変異のために，両者の間に明確な因果関係を見つけることが難しい場合がある。特に半乾燥熱帯では，降雨の年次変動が大きく，人間活動によって引き起こされる生態レジリアンスの変化が判然としないことがままある。サブテーマⅠ-1では，生態レジリアンスに対する人間活動の影響を明らかにするため，詳細な野外実験を行い，生態レジリアンスの指標となりうる測定項目の空間的・時間的変異を解析する。サブテーマⅠ-2 では，さらに生態レジリアンスと人間活動の相互作用を明らかにし，生態資源に大きく依存する半乾燥熱帯の人々が生計を安定化させるために生態レジリアンスの変異に対してどのように対処しているかを解明する。

両サブテーマを組み合わせることで，研究対象地域における生態レジリアンスの現状，人々の生活の生態資源への依存の程度，人間活動による生態レジリアンスの変化の様相を明らかにし，生態資源のよりよい管理手法の開発に資する。

<u>I-1 異なる人間活動と環境変動下での生態レジリアンスの構成要因, 遷移の解明（真常, 田中，三浦，柴田，佐伯）</u>

上述のように生態レジリアンスを定義できるものの，どのような測定可能な指標を用いて評価できるのかは不明なままである。これまでの生態学的研究によれば，生態系内での変異と冗長性がレジリアンスにとって重要であることが示唆されている。そこで当サブテーマでは，休閑二次林から畑への土地利用の変換過程における土地の様々な特性の空間的・時間的変異をモニタリングし，生態レジリアンスを構成する要因やその能力の変遷を追跡する。そのため，ザンビア東部州ペタウケ郊外のミオンボ林において畑に開く処理区を毎年設定し，そのうち一部は研究期間中に耕作をやめ林に戻す。このような処理区を設定することで，人間活動の異なる圧力を受けた土地を用意し，変動する気候因子と人間活動の影響を区別して評価することが可能となる。森林から畑に開いた後の経年変化すべてを人間活動に帰してきたこれまでの研究と大きく異なる利点である。この実験では，土壌特性値，物質循環，植物種，微気象の空間的・時間的変異を測定し，生態レジリアンスを定量的に説明する指標を生成する。プロジェクト後半には，異なる人間活動インパクトや土地利用史を有する処理区を比較することができるので，生態レジリアンスの減少やレジームシフトについて知見を得ることができる。

<u>I-2 異なる農業生態系における生態レジリアンスと人間活動の相互作用ならびに生態レジリアンスの遷移 (田中，真常，三浦，宮崎，佐伯)</u>

半乾燥熱帯においては，ある世帯が生態レジリアンスの異なる複数の土地を利用していることがよく観察される。このような土地管理手法は，環境変動に対処するための「リ

スク管理」であると考えられている。このサブテーマでは，人々が種々の生態レジリアンスに対してどのように対処しているかを，生態レジリアンスに関わる様々な土地の特性のモニタリングと比較から明らかにする。調査対象地は，地形（例えば，谷，低地，台地など），土地利用のタイプや歴史，農業生態的な遷移段階などを異にするように選ぶ。調査では，各世帯の耕作地と休閑地の特性を明らかにするため，GPS による面積の測定，土壌有機物含量や有効土層深のような土壌特性値，植物種の構成などを調べる。テーマⅡ・Ⅲと共同し，これら得られた結果から社会生態レジリアンスの総合的概念を構築する。研究対象地域は，ザンビア東部州ペタウケ周辺と南部州シナゾングウェ周辺を予定している。

テーマ II：変動する環境への家計とコミュニティの反応（テーマリーダー：櫻井武司）

半乾燥熱帯，とりわけ信用市場や保険市場が一般的に未発達なサブサハラ・アフリカの農家家計は，予測できない降雨のリスクに備えたり，事後的に対処したりする様々な手法を発達させている。その手法の中には，借金や贈与のように同じ村や近隣の村に住む親類や友人を頼りにするものがあり，同じ地域の人々が同時に被害に遭うようなひどい旱魃の場合にはうまく機能しない。一方，天然資源に依存する手法も存在する。例えば，森から食物を採取するとか，水分の多い谷底を利用するとかである。このように，ある家計がどの手法を採用するか，またその手法がどれほど有効かは，その家計のもつ資産，その家計が利用できる天然資源，旱魃の程度，コミュニティの特性などの要因によって決まっている。また，天然資源の附存量は，農家家計の旱魃への対処行動により影響を受けることになる。例えば，食物を採取するためにたくさんの家計が森に殺到すれば，その資源は枯渇し，次の旱魃の時にはセイフティネットとしての役割を果たせなくなるだろう。言い換えれば，家計の復元力および生態系の復元力は，動的な相互依存の関係がある。そして，この相互依存のために，半乾燥熱帯の家計はしばしば貧困と環境破壊の悪循環の罠に陥ってしまうのである。この点が，本研究プロジェクトが課題とする問題の根本であり，我々，プロジェクトのメンバーは社会・生態レジリアンス（復元力）の分析が罠からの出口を示してくれると考えている。

社会・生態システムの統合的な分析に資するため，テーマ II では次に示す 4 つのサブテーマにより，不規則な降雨に対処する農家家計の戦略を解明する。まず，テーマ II-1 は，予測不能な事象，すなわち降雨を客観的に測定する。テーマ II-2 は，家計が利用可能な資源，すなわち物的資本，天然資本，人的資本，金融資本，そして社会関係資本の附存量に関係する。テーマ II-3 では，家計の行動，つまり，降雨前のリスク管理行動，雨期の期間中の調整行動，および収穫後のリスク対処行動を分析する。最後にテーマ II-4 で，不規則な環境の下での家計の復元力を，収入の平準化，消費の平準化，さらに栄養状態の点から評価する。各サブテーマの詳細は以下の通りである。

II-1　圃場レベルの降水量の空間的，時間的分布の測定（佐伯，菅野）

半乾燥熱帯では，たとえ一つの村の範囲内でも，降水量の変動が非常に大きいこと

が知られている。しかも，年間降水量が十分に多くても，決定的な発育段階に降雨がなければ，作物はひどく被害を受ける。つまり，降水量の時間的分布もまた重要である。しかしながら，旱魃に関する大半の研究は，地域の気象台で計測した年間降水量を用いている。その理由は，単に，圃場レベルの降水量の空間的，時間的分布を知ることができないからである。これは，既存の旱魃研究の最大の弱点である。したがって，このサブテーマでは，小型降水量計を用いて，すべての調査対象家計の圃場で日々の降水量を計測し，局所における降水量の空間的，時間的分布の特徴を分析する。農家家計にとって，降水は生存のための最も貴重な天然資源であるが，他の天然資源，例えば土壌や植生と異なり，どれほどの資源が利用可能であるか予測することはできない。つまり，降水はリスクのある資源であるということができる。

II-2　家計の資本附存量の調査（櫻井，真常，植生の専門家）

家計がどのように旱魃リスクに備え，いかに事後的に旱魃に対処するかは，旱魃の程度だけでなく，家計が利用可能な資源の量によっても決まる。したがって，テーマ II-2 では，降水量以外の家計の資本附存量について調べる。それらは，天然資本（農地，休閑地，森林，家畜など），物的資本（農機具，家屋など），人的資本（家計構成員の内訳，彼らの教育水準，彼らの健康状態など），金融資本（金を貸してくれる人，贈与してくれる人，貯蓄など），そして社会関係資本（組織や団体への加入，人的ネットワーク，信頼など）。これらの中には，リスクのある資本も含まれる。例えば，家畜や人的資本には病気や死亡が起こる。これらの資本のリスクがどの程度かは，降水量の変動の場合と同様，研究プロジェクトの中で解明していくべき実証的な課題である。一方，土壌や植生は，それらの消失が半乾燥熱帯では深刻な問題ではあるが，研究を実施している短い期間では大きな変動はないであろう。資本附存量に関するデータは，実際の計測および聞き取りにより収集する。本研究プロジェクトで採用している学際的アプローチの利点は，農地の土壌や植生などの物理的実測や家計構成員の健康状態の診査に自然科学の専門家が参加するところにある。

II-3　降水量の変動に対する家計行動の分析（櫻井，農学の専門家）

テーマ II-1 と II-2 で計測した様々な資本附存量を所与とすると，課題は半乾燥熱帯の家計は変動する環境の下でどのように行動しているのかということである。家計行動は，3つのカテゴリーに分類することができる。降雨前のリスク管理行動，雨期の期間中の調整行動，および収穫後のリスク対処行動である。テーマ II-3 では，家計の行動を毎週行う聞き取りにより記録し，そのデータを使って降水量と資本附存量が家計の意思決定にどのように影響しているかを明らかにする。家計の意思決定には，農業生産への投入，農業外への労働供給，家畜やその他資産の取引，貸し借り，贈与のやりとり，支出，消費，などが含まれる。テーマ II-1 で降水量の日量が記録されているので，テーマ II-3 では雨期の期間中に家計が生存戦略をどのように調整するかを明らかにする。データの制約のため，過去には，このような研究はほとんど行われていない。一方，雨期の開始前のリスク管理では，作物の種類と圃場の立地の多様化が降水リスクを緩和する重要な戦略の一つである。その点に関しては，作

物の選択（例えば，旱魃に耐性のある作物か旱魃に弱い作物か），品種の選択（例えば，早生か晩生か），技術選択（例えば，耕起するかしないか）などについて，農学的な観点から分析する。

II-4　家計の復元力の評価（櫻井，身体計測の専門家）

最後にテーマ II-4 では，家計のリスク管理とリスク対処行動を，復元力の観点から評価する。生態系の観点はとりあえず無視して，このサブテーマでは，家計の復元力の評価基準として収入の平準化および消費の平準化を用いる。プロジェクト期間に複数年にわたって実施する家計の毎週聞き取りにより得たデータを使って，年内（つまり季節変動）および年間（つまり降水量による年ごとの変動）について，評価を行う。しかし，この手法については，家計の収入と消費（あるいは支出と自家消費の和）は毎週の聞き取りによっても物理的に計測できないという批判がある。したがって，客観的な指標を得る目的で，身体計測を実施する。つまり，体重と身長の測定である。これらも家計の復元力の評価基準として用いる。

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（テーマリーダー：島田周平）

このテーマでは，半乾燥地域における社会的レジリエンスの制度的側面に焦点をあてる。社会的レジリアンスは，社会的，政治・経済的変化によってのみ影響を受けるものではなく，生態的変化によっても影響を受ける。それは空間的に様々な広がりをもって起きると同時に時間的にも様々な長さで起きる。それ故社会的レジリアンスのシステムを理解しようとすれば，脆弱性増大の過程とそれが緩和される過程を統合的に捉えることが必須となる。このテーマで集約的な地域調査を行うのはそのためである。

社会的レジリエンスを分析するためには，社会の脆弱性増大の過程を理解する必要である。Leach 他（1998)が述べているように，脆弱性には二つの側面がある，すなわち外部的側面と内部的側面である。脆弱性の外部的側面とは，不安定な降水量や価格変動さらには政治的変動からくるリスクやショック，ストレスなどと関係を持つものである。これに対し社会的脆弱性の内部的側面とは，社会が持つ防御能力が欠如していることに関するものである。したがって，社会の脆弱性は，社会や世帯あるいは個人が両方の側面から引き起こされる困難に対応することが出来なくなったときに増大するといえよう。

半乾燥地域は外部的側面のリスクが高い地域に属する。また貧しい人々の防御能力が欠如し，他の人たちよりも脆弱であることは広く指摘されているところである。しかしながら，半乾燥地域の人々が自分たちが住む生態環境に絶望しているわけでもなく，貧しい人々が何もしないで手をこまねいているわけでもない。彼らはリスクを低め適応力を高めるため，さらには自立的な力を高めるため，様々な方法で努力をしている。外部的リスクやショックを回避したり和らげるため様々な方法がとられている。また困難な状態から抜け

出すための戦略もたくさんある。それらは意識的戦略の場合もあるが無意識的なものもある。これらの人々の努力を助けているのが社会制度である。

ということで，このテーマにおける最初の疑問は，様々な戦略や制度を含む社会的装置が存在するにも拘わらず何故半乾燥地域の社会において，脆弱性増大が起きやすいのか？という点に向かう。そして第二の疑問は，そのような脆弱性増大にも拘わらず，何故社会は存続しうるのか？という点に対して起きる。

したがって，このテーマにおいて注目される点は以下の通りとなる。

① 社会的脆弱性が引き起こされた過去の記録を調べる
② 困難や辛苦の経験を聴き取りする
③ 社会の脆弱性増大過程を明らかにする
④ その脆弱性が緩和される過程を調べる
⑤ 脆弱性が緩和される過程で働いていた緩和要因を分析する
⑥ 社会制度が社会的レジリエンスのために働いていた機能について調べる
⑦ 社会的レジリエンスのために作用している事項をすべて見つけ出す

社会はそれぞれ独自の場所と歴史的背景をもっている。この研究では我々は，地域的特殊性に十分な注意を払う。それは社会の多様性を確認するためではなく，地域的多様性を分類することによって一般的要因を導き出すためである。このテーマにおける幾つかのサブ・テーマは以下の通りである。先に挙げた注目点はこれらのサブ・テーマの中で追求される。

III-1　経済環境の変化：農業政策およびそれが農業生産や土地利用に与えるインパクト（児玉谷，半澤，島田，梅津）

政府の政策，とりわけ農業政策の歴史的変化を調べる。そして調査地域の基本的経済状況を理解するため，現在の国際的経済変化のインパクトを分析する。農業生産システムの変化は政策の変化との関連で分析される。

このサブ・テーマで我々は，耕作形態，土地保有制度，食糧のマーケッティング，食糧消費などの変化を調べる。食糧作物の組み合わせの変化や食事の変化に関する研究も行う。

環境悪化はしばしば農業土地利用と生態的レジリアンスとの調和が崩れた結果であると考えられる。トウモロコシの単作栽培拡大やキャッサバ生産の拡大の影響の問題は，ソルガムやミレットの生産減少の影響と一緒にここで検討される。

III-2　政治社会的環境変化：文化変容と制度変容（島田，荒木，カジョバ）

このサブ・テーマでは，農業生産と関連した習慣や社会制度について調べる。伝統的土地保有制度，血縁集団内・血縁集団間の相互扶助システム，地域社会による自然資源管理等の実態が調査される。制度とここで言う場合それは社会的政治的実践として行われている可能性的で動態的なものとして捉えられている。それらは文化や人々の信仰，そして人々の生き様と密接に結びついている。このことは農民の適応戦略といった場合でもそれ

が非経済的理由に動機づけられている場合が少なくないことを暗示している。文化や信仰は人々の行動を決める上で重要な役割を果たしている。

資源管理に関するすべての制度を調べ上げ，脱制度化論的視点から制度について調べる。

III-3　脆弱性の増大と世帯とコミュニティの社会的レジリアンス（島田，梅津，荒木）

干魃や多雨，農産物市場の失敗などに関する人々の記憶を聞き取り調査によって調べる。またその時に農民たちがとった適応戦略との関係も社会経済的変化との関係から調べる。消費の減少，農外労働，資産の売却，コミュニティからの支援，落ち穂拾い，薪の収集，野生の救荒作物の採集，等の適応戦略をとった理由について家畜の所有数や女性家長世帯などの特徴とともに聴き取りを行う。もし違う年代で干魃の記憶が幾つかある場合，それらの出来事について集中的な聴き取りを行う。長い期間をカバーする集約的聞き取り調査を世帯単位で実施することにより，社会的脆弱性が増大し緩和する過程を分析する。

社会的脆弱性が緩和される過程で機能している諸要因を分析することによって，社会的レジリアンスのために働いている全ての事項を探り出す。また，脆弱性を和らげたり無くしたりするために重要な役割を果たしている社会的制度の役割についても研究する。幾つかの農業以外の要因としてHIV/エイズの影響や，NGOの活動の影響，女性世帯の増大の問題もこのサブ・テーマで取りあげる。

テーマIV：社会-生態システムに対する統合解析　（テーマリーダ：吉村充則）

本課題では，生態システムの変遷とそれに対応する社会システムに関する調査から生態システムの脆弱性･レジリアンスと人間活動の相互作用について明らかにする。課題遂行にあたっては，「旱魃」と「食料危機に対する早期警戒システム」をケーススタディーとして取りあげる。

「旱魃」は，そこに住む人々に重大な影響を与える災害のひとつとして知られている。また，「旱魃」は食糧不足を招き，アフリカ諸国の貧困と密接に関係する。そのため，食料危機に対する国レベルでの効果的な早期警戒システムの構築が早くから模索されてきた。ここでは，「旱魃」の発生メカニズム並びに被害状況を，1)大陸レベル(Continental/Global Level)・2)国レベル(Country Level)・3)村落レベル(District Level)といった異なる３つの空間レベルからモニタリングする。さらに，これらの結果と国レベルで対応されている早期警戒システムの農村への対応が農村社会のレジリアンスに与える影響について明らかにする。

IV-1　　環境変動のグローバルモニタリング (佐伯，気候学専門家，吉村)

研究対象であるアフリカの半乾燥熱帯地域をアフリカ全体から気候学的，地政学的(いわゆる人文科学的)に特徴付ける。気候学的な研究からは，アフリカ大陸全体の気候変動のモニタリングによって，旱魃などの自然災害の発生メカニズムを明らかにする。地政学的な

研究では，旱魃などの自然災害によってもたらされる人的被害についての調査を行い，それが農民社会に与える影響について人口動態などから明らかにする。

IV-2　土地利用変化と生態システムへの影響モニタリング (吉村, 文化人類学専門家, 山下)

国あるいは地域レベルで旱魃などの環境変動が生態システムに与える影響を知るために，森林破壊や緑地面積の減少といった観点から調査を実施する。時系列な衛星画像や航空写真などを用いて土地被覆や利用がどのように変化し，その結果，地域の住民にどのような影響(人の動き)が出たのかを検討する。さらに，それらを引き起こした歴史的･社会的背景についても調査する。

IV-3　早期警戒システムと食料安全保障 (梅津，文化人類専門家，吉村)

サハラ以南のアフリカが直面する最大の緊急課題である食料安全保障について知るために，WFP の早期警戒システムについて調査する。また，実際に旱魃などの自然災害を受けた地域に対する現地調査を通して，早期警戒システムが農民社会に対しどのような機能を果たしているか，もしくはその課題について明らかにする。さらに，農民社会のレジリアンスにとって，これらの活動がどのような影響を与えるかについても明らかにする。

IV-4　旱魃への対応とレジリアンス指標の郡レベル分析（梅津，佐伯，桜井，島田，真常，田中，吉村）

１）社会経済指標，農業生産，穀物価格に関する郡レベルでの統計データを中央統計局と農業省より入手する。２）中央統計局の収穫予測調査及び収穫後調査はプロジェクトが実施する予定の２００６年再調査データと統合される。３）郡レベルデータは社会経済，制度的要因，農業生態的要因とともにレジリアンス指標のマッピングに利用する。４）統計情報は農家世帯のインタビュー調査によって補足され，社会経済指標は降雨量や土壌肥沃度等の農業生態の情報と重ね合わせ分析する。

2. 進捗状況

2.1 FS 研究での活動成果

A. 研究体制の構築

- ４つのテーマを設定し，その研究内容実施に適した土壌学，農学，開発経済学，資源経済学，人類学，環境地理学，気候学，リモートセンシング等必要な人材の確保を行った。
- ザンビア，インド，ブルキナファソでの研究協力者の発掘及び研究支援体制の準備を行った。
- ザンビアでのフィールド調査実施のため主要メンバーの 2006 年から 2011 年までの調査許可証をザンビア大学社会経済研究所（ISER/UNZA）の協力で入手し，2006 年度からのフィールド調査に備えた。コアメンバーの ISER/UNZA とのアフィリエーションの手続きはすでに完了している。

B. 方法論の検討成果

平成１７年度は，文献調査およびフィールドでの観察，予備的聞き取り調査によりレジリアンス研究のためにターゲットとするべき調査項目の特定を行った。詳細は前のセクションに記載されている。

C. 予備調査等の成果

• ―ザンビアの 2004/5 年の作物シーズンは 1991/2 以来の大旱魃となり，東部と南部で主食のメイズ 85-90%が大打撃を受けた。

•一方，旱魃に強い品種が普及している綿花は着実に近年作付面積を伸ばしているが，食料安全保障の観点からの検討が必要である。

• 2005 年 8 月のザンビア調査では，南部と東部の調査候補地の視察を行った。また気象局から気象データを一部入手した。また国土省測量局からは地理データの情報を入手した。

• 11 月のザンビア調査では, 旱魃年の 2004/5 年にザンビア全国の農家 8000 世帯を対象に実施された収穫予測調査 (Crop Forecast Survey) のデータを中央統計局 (Central Statistical Office) より入手した。今後その前後２００４年と２００５年の収穫量データ(Post Harvest Survey)も入手予定。

• ザンビア大学社会経済研究所，同農学部，農業組合省中央農業研究所，中央統計局，国土省測量局，交通通信省気象局，ミシガン大学・アメリカ援助庁・食糧安全保障研究プロジェクト等の関係者と面談し，研究協力体制の構築を行った。

D. ＩＨＤＰ第６回オープンミィーティング（ボン）

• １０月９－１３日に Bonn で開催されたＩＨＤＰ第６回オープンミィーティングでセッション企画を行った。(Theme 1: Adaptive Management and Resilience; Session 1.4 Local Responses to Environmental Stress and Risks; Session Organizers: Chieko Umetsu; Keisuke Hoshikawa, RIHN)

E. 平成１７年度（FY2005）に開かれたＦＳミィーティング

• 第７回レジリアンスセミナー

日時：２００５年４月２８日（木）１５：３０－１７：００

場所：地球研会議室

タイトル：「生業活動と環境保全の両立を目指す村落開発の試みータンザニアでの事例からー」

発表者： 京都大学大学院地球環境学堂 陸域生態系管理論分野・助教授，田中樹

• 第８回レジリアンスセミナー

日時：２００５年６月１０日（金）１１：００－１２：１５

場所：地球研会議室

タイトル：「湖沼生態系のレジリアンスに関する最近の研究紹介」
発表者：地球研・助教授　谷内　茂雄

- 第９回レジリアンスセミナー

日時：２００５年7月２１日（木）１５：００－１７：１５
場所：地球研会議室
タイトル：「ザンビア東部における社会変容と農地利用の変化－チェワ農民による新しい畑の創出をめぐって－」
発表者：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，吉川竜太
タイトル：「コーヒーの国際価格変動に対する農村社会の対応―エチオピアにおける 1990 年代の経済自由化と『コーヒー危機』」
発表者：京都大学大学院人間・環境学研究科・助手，松村圭一郎

- 第１０回レジリアンスセミナー

日時：２００５年１０月２１日（金）　１５：００－１７：３０
場所：地球研会議室
タイトル：「持続可能な開発」理念の再構築：生態系レジリアンスを軸として
発表者：（財）地球環境戦略研究機関（IGES）長期展望・政策統合プロジェクト研究員，小嶋公史（こじま　さとし）

- 第１１回レジリアンスセミナー

日時：２００５年１１月２５日（金）　１５：００－１７：３０
場所：地球研会議室
タイトル：「西アフリカ，マリ共和国における現地気象観測（２００１－２００４）」
発表者：(独) 農業・生物特定産業技術研究機構東北農業研究センター連携研究第１チーム長，菅野　洋光　（かんの　ひろみつ）
タイトル：「圃場特異的な降水量変動に農家はいかに対処しているか：西アフリカ，マリにおける実証」
発表者：農林水産省　農林水産政策研究所　アジアアフリカ研究室　主任研究官，櫻井　武司

- １２月９日　ＦＳメンバー会議　１１：００－１６：４５　地球研会議室

2.2 研究遂行上の問題点と解決方法

A. IS・FS の結果明らかになった問題点と解決方法

レジリアンス研究は理論が先行しているが，具体的な途上国の開発問題に応用した先行研究はまだ少なくこれからより地域的な問題への対応が求められる。そのため，地域に密着したテーマ I, II, III を設定し，広域のテーマ IV につなげる計画である。

B. 当初計画からの変更点

IS・FS では調査対象地域をザンビアと南インドに限定したが，今後調査対象地域は半乾燥熱帯 (Semi-arid tropics: SAT) へと拡大する予定である。これによって自然資源への依存度が高いブルキナファソ，人的資源への依存度が高いインドを含め，人口や土地その他資源賦存量の違いによるレジリアンス比較も視野に入れることが可能となる。

3. 平成１８年度から平成２３年度までの調査活動

3.1 年度別スケジュール

	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	xx	x
II. 旱魃と世帯・地域	x	xxx	xxx	xxx	xxx	xx	x
III. 脆弱性と制度・歴史	xx	xx	xxx	xxx	xxx	xxx	x
IV. 広域と統合解析	x	xx	xxx	xxx	xxx	xxx	xxx
インド		x	xx	xx	xx	xx	x
ブルキナファソ			x	xx	xx	xx	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

PR (平成１８年度：FY2006)

I: ペタウケ周辺のミオンボ休閑林でのモニタリング試験区（ペタウケ試験区）の設定；ミオンボ休閑林の開墾準備（樹木の環状剥皮など）；ペタウケ周辺（東部州）とシナゾングウェ周辺（南部州）の土壌，地形，植生分布の予備調査；他課題と連動しながらの，調査対象世帯の選定

II: 調査地の選定（ザンビア東部州ペタウケ郡から４村，南部州シナゾングエ郡から４村）それぞれの郡の代表性すなわち郡首都からの距離や降雨量などの違いを考慮に入れて選定を行う。それぞれの村でセンサスを実施し，それに基づいて家計を階層化し，各階層からサンプル家計を選定する。

III: III-1 の研究に必要な文献と統計データを収集する。ザンビア中央州，南部州，東部州から３村かそれ以上を III-2 と III-3 のために選定する。

IV: 調査資料データのデータ源情報調査とデータ取得およびデータベース化; 国際機関における 90 年代にアフリカで起きた旱魃に関する諸情報収集; 気象ステーション設置のための設計

FR1 (平成１９年度：FY2007)

I: ペタウケ試験区への気象観測装置（降雨計，土壌水分温度計など）の設置と観測の開始；ペタウケ試験区のミオンボ休閑林の開墾（Y1 プロット）および農地化への過程の記録（伐採，薪炭材の獲得，火入れ，整地，播種，除草など）；ペタウケ試験区での土壌と植生の調査，試

料採取，分析；ペタウケおよびシナゾングウェ周辺の調査世帯の所有地(耕地，休閑地)の GPS 測量と耕圃ごとの利用状況の聞き取り；農耕技術体系（農具，作業手順，栽培作物，農事暦など）および土地利用類型の調査

II: １０月に雨季が始まる前に雨量自動観測装置を設置する。毎週家計インタビューを雨季の前に開始する。土壌サンプリングと植生調査を雨季の間に実施する。雨季の間と収穫後の少なくとも年に２回，身体計測を実施する。得られたデータは II-1, 2, 3, 4 のサブテーマと共有する。

III: 参加型手法による集中したフィールド調査を開始し，家族構成，農業生産システム等の世帯レベルの情報を収集する。これはサブテーマ III-2, III-3 の基礎的研究となる。

IV: PR でデータベース化したデータに対するデータ解析: 1) 気象データによる旱魃位置と時期の限定; 2) 衛星データによる旱魃被害状況の把握; 3) 人口データによる人口動態の地域間比較; 気象ステーションの設置; 旱魃と人口動態に関する相関分析; 比較検討可能な国と地域の選定(候補はエチオピア).

FR2 (平成２０年度：FY2008)

I: ペタウケ試験区での気象観測の継続；ペタウケ試験区でのミオンボ休閑林の開墾（Y2 プロット），Y1 プロットでの耕作，これらのプロットでの土壌と植生の調査，試料の採取と分析，収量調査；ペタウケおよびシナゾングウェ周辺の調査世帯の所有地(耕地，休閑地)の GPS 測量の完了，新規耕作地や休閑地の追加的 GPS 測量，耕圃ごとの利用状況の聞き取りの継続；生業活動（農業以外の農閑期の出稼ぎ，自家醸造，家畜飼養，採集・漁労などの副生業）の聞き取り；インド亜大陸半乾燥地での比較対照調査の開始

II: FR1 と同じ

III: III-2 と III-3 の集中的調査を継続する。社会的脆弱性に起因する困窮や困難の記録と記憶を聞き取り調査する。

IV: ペタウケ/シナゾングエ地区における旱魃レベルの傾向分析; 早期警戒システムに関する調査と 90 年代の旱魃に対する対応に関する事例研究(候補はエチオピア)。

FR3 (平成２１年度：FY2009)

I: ペタウケ試験区での気象観測の継続；ペタウケ試験区でのミオンボ休閑林の開墾（Y３プロット），Y1・Y2 プロットでの耕作，これらのプロットでの土壌と植生の調査，収量調査，試料の採取と分析；ペタウケおよびシナゾングウェ周辺の全調査世帯の所有地の利用状況の聞き取りの継続，新規耕作地や休閑地の追加的 GPS 測量，土壌調査，植生構成種の調査，，収量調査，試料の採取と分析；西アフリカ内陸半乾燥地での比較対照調査の開始

II: FR1 と同じ

III: 集中的調査を継続する。聞き取りの焦点は社会的脆弱性の増大とその緩和に当てられる。

IV: 気象ステーションでの観測データを用いた District レベルでの季節変化/日変化把握; 空中写真による旱魃前後の農業的土地利用把握と村落形態の変化抽出; ペタウケ/シナゾングエ地区の複数の村落に対する聞き取り調査; PR2 の事例研究(候補はエチオピア)対象地域の村

落に対する聞き取り調査。

FR4 (平成２２年度：FY2010)

I: ペタウケ試験区での気象観測の継続；ペタウケ試験区でのミオンボ休閑林の開墾（Ｙ４プロット），Y1・Y2・Y3 プロットでの耕作，これらのプロットでの土壌と植生の調査，収量調査，試料の採取と分析；ペタウケおよびシナゾングウェ周辺の全調査世帯の所有地の利用状況の聞き取りの継続，新規耕作地や休閑地の追加的 GPS 測量，植生構成種の調査，収量調査
II: FR1 と同じ
III: 集中的調査を継続する。サブテーマ III-3 の研究を開始し，社会の脆弱性とレジリアンスの形成のために果たす社会的制度の機能の分析を行う。
IV: ザンビアにおける調査データを基にした旱魃被害と人口動態の相関についてのモデル構築; ザンビア調査で構築したモデルの事例研究地域における応用可能性に関する検証。

FR5 (平成２３年度：FY2011)

I: ペタウケ試験区での気象観測の継続；ペタウケ試験区でのミオンボ休閑林の開墾（Ｙ５プロット），Y1・Y2・Y3・Y4 プロットでの耕作，これらのプロットでの土壌と植生の調査，試料の採取と分析，収量調査；ペタウケ試験区の土壌および植生の経時的空間変動の解析；ペタウケおよびシナゾングウェ周辺の全調査世帯の所有地の利用状況の聞き取りの継続，新規耕作地や休閑地の追加的 GPS 測量，土壌調査，植生構成種の調査，収量調査，試料の採取と分析；生態レジリアンスの構成要件と幾つかの指標，人為的圧力との関係に関する考察；SAT 各地域（南アフリカ，西アフリカ，インド）間の比較分析と生態レジリアンスを生かす適正な生態・資源管理法のオプションの考察
II: FR1 から FR4 までの４年間で収集されたデータの分析
III:リスク回避，困難への対応，困窮からの回復に貢献した社会的レジリアンスのポートフォリオを見つけることを目的とする。
IV: 生態システムと社会システムとの統合解析

3.2 評価委員会までに達成する予定の成果

A. 平成１７年度（FY2005）評価委員会までに達成する予定の成果

- 2006 年 3 月までに FS 報告書を作成する。
- 中央統計局が収穫予測調査を実施した南部州と東部州のサンプル世帯のみに 2006 年夏に追加調査を依頼できるかどうか中央統計局と調整する。
- 参加を期待される研究分野での人材の確保

B. 平成１9 年度（FY2007）評価委員会までに達成する予定の成果

I-1. 生態レジリアンスの構成要件とそれを表現する幾つかの指標が明らかになる。
II-1. 降雨の空間，時間分布の計測及びそれらの家計行動への影響
III-1. 複雑な過程である脆弱性増大や脆弱性緩和の過程が，まずは地域的特殊性の中で明ら

かにされ，一般化の基礎となる。
IV-1. 旱魃などの自然災害の発生メカニズムを明らかになる。また，自然災害が農民社会に与える影響についても明らかになる。

C. 平成２３年度（FY2011）評価委員会までに達成する予定の成果
I-1. 生態レジリアンスの構成要件とそれを表現する幾つかの指標が明らかになる。
I-2. 生態レジリアンスと人為的圧力との関係が明らかになる。
I-3. 生態レジリアンスを生かす適正な生態・資源管理法のオプションが示される。
II-1. 降雨の空間，時間分布の計測及びそれらの家計行動への影響
II-2. 降雨リスクを緩和し，旱魃のショックに対処するために家計が依存するさまざまな資源の計量的評価
II-3. 家計のレジリアンス指標としての家計収入，消費平準化の計量的評価
III-1. 複雑な過程である脆弱性増大や脆弱性緩和の過程が，まずは地域的特殊性の中で明らかにされ，一般化の基礎となる。
III-2. 社会的レジリエンスの理解にとって必須の，脆弱性を緩和するように働く諸要因あるいは諸要因の組み合わせが明らかにされる。
III-3. 上記の結果は，環境悪化が社会と自然環境の調和の崩壊を反映しているとする仮説を検証することに役立つ。
III-4. 環境と人間社会との調和的関係の構築のために役立つ，地域社会が基礎になった自然資源管理制度の創生や再生に役立つ考えを打ち出す。
IV-1. 旱魃などの自然災害の発生メカニズムが明らかになる。また，自然災害が農民社会に与える影響についても明らかになる。
IV-2. 旱魃などの環境変動が生態システムに与える影響が明らかになる。地域の住民への環境変動の影響が明らかになる。環境変動を引き起こした歴史的･社会的背景についても明らかになる。
IV-3. 早期警戒システムが農民社会に対しどのような機能を果たしているか，もしくはその課題について明らかになる。さらに，農民社会のレジリアンスにとって，これらの活動がどのような影響を与えるかについても明らかになる。
IV-4. レジリアンス指標とマッピングにより旱魃常襲地域においてコミュニティのレジリアンスを高めるための有用な情報を提供する。

4. 共通の課題・議論

4.1 地球研のプロジェクトとして

A. 何故，地球研のプロジェクトとして実施するのか

地球研のプロジェクトとして研究を実施した場合，今まで他の研究費で実現不可能であった研究内容に挑戦することが可能となる。６年間という長い研究期間と予算がそれを可能にしている。レジリアンス・プロジェクトでは，森林伐採実験，広範囲での農家世帯調査と圃場レベルの土壌・降雨量データ収集をプロジェクト全期間に渡って実施する予定である。特に社会・生態システムのレジリアンス研究には多分野の研究者の参加が必要であり，学際プロジェクトへの地球研の支援体制が強力なサポートとなる。

B.「地球環境問題」の認識

環境資源に生産活動を依存する人々は環境変動に対して脆弱な生活を営んでおり，それが貧困と環境破壊の悪循環の原因となっている。この悪循環は重要な「地球環境問題」として認識され，2005 年 3 月に開催された環境開発大臣会議でも特にサブサハラ・アフリカ地域での人間環境に対する地球温暖化の影響調査の必要性が強調された。そこで，本プロジェクトでは国際社会で重要な「地球環境問題」と認識されている半乾燥熱帯地域での環境変動の影響と人間社会のレジリアンスについて考察する。

C. 対象地域と「地球環境問題」の関係

本プロジェクトは南アフリカ地域（ザンビア，ジンバブエ等），西アフリカ地域（ブルキナファソ，ニジェール等），及び南アジア（インド等）の半乾燥熱帯(semi-arid tropics: SAT)地域を調査対象とする。この地域では，人々の生業は天水農業に依存し，環境変動に対して最も脆弱であると考えられている。人々の生業活動に起因する森林破壊や砂漠化などの地球環境問題が顕著に現れており，その問題解決のために食糧安全保障やレジリアンスの向上，貧困削減が緊急の課題となっている。

D. プロジェクトの成果がどのように「地球環境問題」の解決に資するのか

本プロジェクトでは，社会・経済システムの脆弱性に起因する環境劣化を「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，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。本プロジェクト期間中，現地での測定，観察，分析を通してレジリアンスの鍵となる指標を検討し，その指標を用いて生態系と資源管理へのオプションを提示する。

4.2 「総合性」「学際性」の実現

A. 方法・体制などの特徴と問題点

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。今後の活動への参画を望む研究分野は人類学，

社会学，森林生態学，農業気象学，保健衛生学等。他のプロジェクトとの連携として，同様の関心・目的を持つプロジェクトと合同でワークショップを開催する。

B. 参加が期待される専門分野・研究グループ

- 身体計測専門家，マクロ経済学者，文化人類学者

- インド：タミルナドゥの水資源管理と人間の安全保障（梅津，Palanisami，谷田貝，Geethalakshmi，櫻井他：平成１８年度開始）

―タミルナドゥ州はインド全体の５％の土地面積と７％の人口を擁し，州の労働人口の６割は農業に従事している。近年，地下水の過剰揚水と溜池灌漑地域での農業用水の枯渇が農業地域の持続性にとって主要な問題となっている。この研究は以下を目的とする。１）モンスーン雨の気象データを蓄積し，州の降雨量パターンを分析する；２）降雨の流域への流れを水文学的ツールによって分析する；３）水資源の枯渇に対する農民と地域の対応を分析する；４）農村地域のレジリアンスと持続性を高める方策を考える。

- ブルキナファソ：土壌資源と人間の安全保障（田中，櫻井，宮嵜他：平成１９年度開始）

―ブルキナファソの農業地域の土壌資源は人口増加，農業の集約化，人口移動等の要因により劣化の危機に曝されている。ブルキナファソの資源に乏しい農業地域で土壌劣化を起こすさまざまな社会的，物理的要因を分析する。

C. 他の地球研プロジェクトとの連携

他のプロジェクトとの連携として，同様の関心・目的を持つプロジェクトと合同でワークショップを開催する。共同で出版することも連携のオプションのひとつである。

4.3 具体的提言に向けて

研究成果を本や論文として出版し，ワークショップや国際学会などで発表すると同時にホームページで発信する。IHDP 等の国際的研究コミュミティーに積極的に参加する。ザンビア国内での関係者とのワークショップにより研究交流・議論を深め成果を提言する。

<u>出版</u>

１．ワークショップ報告書の出版（年報）
２．国際ワークショップからの書籍出版（日本，ザンビア，他）
３．学術ジャーナルへの出版

<u>発表</u>

１．国内と海外でのワークショップでの発表
２．ＩＨＤＰ等の国際的研究コミュミティーでの発表とセッション企画
３．学会での発表とセッション企画

<u>発信</u>

１．プロジェクト・ホームページでの研究成果の公開

２．公開フォーラムでの一般に向けた研究成果の発信

5. 参考文献リスト

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１－3PRプロジェクトメンバー表 （平成１８年度）

	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	助教授	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	総合地球環境学研究所	研究部	助教授	数理生態学	アドバイザー
	Theme I						
○	真常　仁志	シンジョウ　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	助手	土壌資源学	土壌有機物の分解・肥沃度測定
○	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	助教授	境界農学	土壌劣化の経時的計測
	柴田昌三	シバタショウゾウ	京都大学大学院地球環境学堂	景観生態保全論分野	助教授	森林生態	樹木構成種調査
	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	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	博士課程後期	土壌資源学	土地利用・履歴調査
	Moses Mwale		Mt.Makulu Central Research Station		Chief Agricultural Research Officer	土壌学	土壌分析
	Theme II						
○	櫻井　武司	サクライ　タケシ	農林水産省農林水産政策研究所	国際政策部アジアアフリカ研究室	主任研究官	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・生物特定産業技術研究機構　東北農業研究センター	連携研究第1チーム	チーム長	農業気象	気象観測
	Theme III						
○	島田　周平	シマダ　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	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	COE研究員	開発学	農村社会・制度調査
	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
	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
	Chileshe Mulenga		University of Zambia	Institute of Economic and Social Research	Senior Lecture	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	総合地球環境学研究所	研究推進センター	助教授	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	助教授	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	総合地球環境学研究所	研究部	助手	大気物理学	気候モニタリンク
	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
	India						
○	K. Palanisami		Tamilnadu Agricultural University	Water Technology Centre	Director	農業経済学	農村世帯調査・分析
	谷田貝亜紀代		総合地球環境学研究所	研究部	助手	気象学	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	Tamil Nadu Rice Research Institute	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

○＝コアメンバー; A = アドバイザー

平成１７年度レジリアンス研究会要旨

第７回レジリアンス研究会（梅津ＦＳ）

日時：２００５年４月２８日（木）１５：３０－１７：００
場所：地球研会議室

タイトル：「生業活動と環境保全の両立を目指す村落開発の試みータンザニアでの事例からー」
発表者：　京都大学大学院地球環境学堂 陸域生態系管理論分野・助教授、田中樹（たなか　うえる）

［要旨］東アフリカの山地帯では、増加する土地圧力の下、生態環境や土地資源が急激に劣化しつつある。深刻な現実として、劣化の主な原因は、食料や世帯収入を得るための現地の人々による日常的な生業活動である。人々のニーズとこれらの問題を同時に解決し、加えて地域社会の活力を高めるような具体的な活動オプションを示すことが強く求められている。この発表では、タンザニア東部のウルグル山塊での村落開発活動を通じて得られた経験や発見を、特に住民参加が持つ潜在性や在来生業システムにある知識や技術の活用の仕方、そして関与する外部者の役割に注目しつつ紹介する。紹介する活動オプションの例は、「養蜂を通じての木を植えないで森を回復する活動」、「伝統的な焼畑耕作が持つ潜在的な食料安全保障の仕組みの再評価」、そして「伝統的屋敷林システムの構成要素にバニラを加えることによる焼畑耕作での間接的な労働負荷の軽減と世帯収入源の創出」である。

第８回レジリアンス研究会（梅津ＦＳ）

日時：２００５年６月１０日（金）１１：００－１２：１５
場所：地球研会議室

タイトル：「湖沼生態系のレジリアンスに関する最近の研究紹介」
発表者：　地球研・助教授　谷内　茂雄

[要旨] 湖沼生態系におけるレジリアンスに関する、最近の研究紹介をおこなった。最近の生態学における、生態系に関する見方の変化、レジリアンスという考え方の意味を整理し、Carpenter などによる実験と比較、モデルを組み合わせた、湖沼のレジームシフト研究の紹介をおこなった。参考文献：Kathryn L. Cottingham and Stephen R.

Carpenter "Predictive Indices of Ecosystem Resilience in Models of North Temperate Lakes" Ecology, 75(7), 1994, pp.2127-2138.

第９回レジリアンス研究会（梅津ＦＳ）

日時：２００５年7月２１日（木）１５：００－１７：１５
場所：地球研会議室

１５：００－１６：００
タイトル：「ザンビア東部における社会変容と農地利用の変化－チェワ農民による新しい畑の創出をめぐって－」
発表者：　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
　　吉川竜太

[要旨]　1980年代半ば以降の農業政策の変遷に農村社会がどのように対応してきたのか、栽培作物と農地利用に焦点を当て明らかにする。また、その対応と居住形態の変化との関連性についても考察する。

１６：００－１７：００
タイトル：「コーヒーの国際価格変動に対する農村社会の対応―エチオピアにおける1990 年代の経済自由化と『コーヒー危機』」
発表者：　京都大学大学院人間・環境学研究科・助手、松村圭一郎

[要旨]　コーヒー価格自由化後の経済変動のなかで、コーヒー栽培に依存する農村部がいかに対応してきたのか。価格の乱高下に見舞われた 1990 年代半ば以降のローカル 社会の動きを、土地利用変化など農民の生業活動の変化と社会変容という面から捉える。

１７：００－１７：１５　総合討論

第１０回レジリアンス研究会（梅津ＦＳ）

日時：２００５年１０月２１日（金）　１５：００－１７：３０
場所：　地球研会議室

タイトル：「持続可能な開発」理念の再構築：生態系レジリアンスを軸として

発表者：（財）地球環境戦略研究機関（IGES）長期展望・政策統合プロジェクト研究員、小嶋公史（こじま　さとし）

[要旨] 1987 年に出版されたブルントラント報告書によって提唱されて以来、「持続可能な開発」の理念は人類共通の目標として、国際政治の場をはじめ様々なレベルで使用されてきた。しかし「持続可能な開発」が具体的に何を意味するのか、その実現にはどのような施策が必要なのかについて、膨大な議論・研究がなされてきたにも関わらず、共通の認識は形成されていない。本発表では、「持続可能な開発」の目的を「持続可能性に関する制約条件を満たした上で、現代世代の貧困を撲滅すること」と定義し、持続可能性制約条件として「生命維持システムを支える生態系のレジリアンスを損なわないこと」と定義することを提言する。その中で、持続可能性を追及する学問としてのエコロジー経済学の最近の動向について触れる。また、そのように定義された「持続可能な開発」を政策分析に反映する試みの一つとして、モロッコの水問題を対象としたケーススタディについて簡単に紹介する。

第１１回レジリアンス研究会（梅津ＦＳ）

日時：２００５年１１月２５日（金）　１５：００－１７：３０
場所：　地球研会議室

１５：００－１６：００
タイトル：「西アフリカ、マリ共和国における現地気象観測（２００１－２００４）」
発表者：（独）農業・生物特定産業技術研究機構東北農業研究センター連携研究第１チーム長、菅野　洋光　（かんの　ひろみつ）

[要旨]　西アフリカマリ共和国において、JIRCAS のプロジェクト「西アフリカの気象変動予測の高度化による穀物生産のリスク軽減技術の開発」のもと、2001 年～2004 年まで現地気象観測を行った。マリの南西部の 2 つの村を調査サイトとして選定し、それぞれに気象観測装置 1 台（気温・湿度・風・気圧・雨量）と雨量計 15 台を展開し、村の気象状況を詳細に観測した。その結果、①降水量の村内の特徴的な分布パーン、②朝と夕に集中する降水現象、③雨季のステージが分かれること、④湿度・気圧等の特徴的な季節変化、などが明らかになった。この他、気象台の観測データ解析による降水帯の季節内移動の把握、高層データ解析による季節変化の把握なども行った。さらに、①空港からの機材持ち込みに関するトラブル、②シロアリに木製台座が食われて雨量欠測事件、③牛にケーブルをかじられて欠測事件、④原因不明のデータロガーストップ現象、など、失敗談も入れてご紹介したい。最後に東北地方における農業と気象について手短にご紹介して、アフリカとの比較を行えればと思っている。

１６：００－１７：００
タイトル：「圃場特異的な降水量変動に農家はいかに対処しているか：西アフリカ，マリにおける実証」
発表者：農林水産省　農林水産政策研究所　アジアアフリカ研究室　主任研究官、櫻井　武司

[要旨]　JIRCAS の「西アフリカの気象変動予測の高度化による穀物生産のリスク軽減技術の開発」プロジェクトでは，2001 年～2003 年にわたり，マリの南西部の 2 つの村で農家家計調査と現地気象観測を行った。それぞれの村の各所に設置した 15 台の雨量計により各圃場の降水量を測定したところ，農家は自分の圃場の降水量変動を経験的に予測し保険的行動を行っていること，また自分の圃場で少雨を経験した農家は事後的な所得補償行動をしていること，を確認した。このことは，一つの村という狭い空間内においても，降水量の変異は大きく，それに対処する農家の行動にも多様性があること示している。すなわち，地域レベルで定義する「旱魃」は，個々の農家の経済厚生を必ずしも反映していない可能性がある。

１７：００－１７：３０　総合討論

ザンビア・フィールド調査報告（梅津、吉村、佐伯）

2005 年 8 月 1-13 日

０．まとめ

南部アフリカ地域では、2004/5 年の旱魃の影響によりメイズ生産が打撃を受け、特に Lesotho, Malawi, Mozambique, Swaziland, Zambia, Zimbabwe で 1 千万の人口が 811,000MT の人道的食糧援助を必要としている。一方 South Africa, Angola, Tanzania では昨年より豊作であった。

ザンビアでは 2004/5 年の雨季は 91/92 年以来の旱魃となり、特に南部州と東部州でメイズが大きな被害を受けた。ザンビア政府は Disaster Management & Mitigation Unit/Office of the President が被害を受けた地域への食糧援助を開始している。Zambia Vulnerability Assessment Committee (VAC)の報告では、118,000MT の穀物を必要としている。

Central Statistical Office と Food Security Research Project では毎年全土で Post Harvest Survey と Supplementary survey を実施し、家計調査を行っている。今回の調査では今年の旱魃で影響を受けた地域とその地域での PHS/SS の対象地域についての情報を関連省庁および現場から入手することを行った。具体的には 4 州、5 郡について SEA (standard enumeration area) のリストと地図を CSO から入手した。

1. Southern Porvince (Choma, Sinazongwe Districts)
2. Eastern Province (Petauke District)
3. Lusaka Province (Luangwa District: vulnerability assessment で highly vulnerable と評価されている Zimbabwe, Mozambique 国境)
4. Central Province (Kabwe District)

レジリアンス・プロジェクトの調査対象地区としては 2004/5 年の旱魃被害地で CSO/FSRP の SEA の情報がある近辺をターゲットにすることが可能性として考えられる。今回訪問できた SEA は Sinazese, Sinamalima (Sinazongwe District), Minga (Petauke District)であった。

１．行動日程メモ

８月１日（月）21:00 にカウンター前に集合（高速道の事故でＭＫが遅れる）
出発ロビーの銀行は 22:30 まで、地下の Lawson は 22:00 以降も営業
関空発(23:15 EK317)

８月２日（火）ドバイ着(5:10) ドバイ発(9:55 EK763) ヨハネスブルグ着(16:15)
*空港内の薬局でマラリヤ薬(mefliam)を購入 16USD/box(6tablets)
ヨハネスブルグ発 (18:10 SA68) ルサカ着(20:10) Juls Guest House 到着 (21:10)
SA 航空のストのため梅津と佐伯を含む多くの乗客の荷物が不着。なぜか吉村さんの荷物だけ到着する。

８月３日（水）ルサカ市内

9:30　Dr. Mulenga が Chipata 行きを遅らせて Juls Guest House まで我々に会いに来てくれる。

10:45　Manda Hill で換金（１USD＝4,630ZK）

11:45　SA 航空オフィス(Intercontinental Hotel 2F)へ荷物の件で問い合わせに。

12:30　Alliance Francaise で昼食

14:05　Survey Department, Ministry of Lands (Mulungushi House)訪問、Mr. Mubanga は不在

14:37　FAO Zambia Office の Library で Mr.Daka に資料のコピーを依頼

15:25　Meteorology Department で気象データの情報収集

16:55　Juls Guest House　夜空港へ荷物を取りに行くがまだ到着していなかった。

８月４日（木）ルサカ市内

9:00　Dr. Jones Govereh を Food Security Research Project Office (Rhodes Garden)に訪ね情報収集

10:30　SA Office から再び空港へ行きようやく荷物を自力で発見（鍵のかかったコンテナ３台分の荷物が山済みのままだった）

11:55　Arcade で昼食と e-mail

14:45　Murngushi House へ再度行くが Mr.Mubanga は不在。１１日に再訪することにする。

15:15　Central Statistical Office/Sales and Dissemination Office で資料の購入、ここで紹介してもらった Mr. Frank Kakungu (Head: Living Conditions), Mr. Sooka (Head of Agriculture)を訪ねるがあいにく不在。

16:12　Arcade で給油（petrol: 5,420ZK/litre）, SPA で飲料水他の調達

16:51　Juls 着

８月５日（金）ルサカ～チョマ

10:35　Juls 発　Ndola の精製所が故障のためディーゼルがザンビア全土で不足し予約していた 4x4 が使えなくなる。代わりにミニバスでようやく出発（乗り合いバスと同じタイプ）

11:50　Kafue junction

12:38　Mazabuka (Shopping Centre で昼食) 13:28 発

14:00　Monze

14:30　Pemba

15:10　Choma-Provincial Agricultural Coordination Office を訪ね、Provincial Agricultural Coordonator (PACO)の Mr.Collins Nkatiko 氏から情報収集し、Sinazeze の Mr.George Munakango 氏を案内人として紹介してもらう。Sinazongwe District の SEA(Standard Enumeration Area)がどこなのかを聞き出す。Choma Weather Station へも連絡して我々がスタッフに会える様手配してくれる。ラジオ無線でどこにでもすぐ連絡が出来るのはすごい。Choma 市内には Oxfam, World Vision 等 NGO の看板が目立つ。ここを拠点にして活動しているもよう。

16:35　Choma から 10 km 離れた Weather Station を見学。降水量 850mm（平年）524mm (2004/5)

17:30　Kozo Lodge 着(150,000ZK/night)

８月６日（土）チョマ～カリバ湖畔～チョマ

8:07　Kozo Lodge 発

8:17　Choma で給油　(5724ZK/litre: 273,035KW)　Batoka へ戻り舗装道をカリバ湖へ南下。

9:28　Sinazese で Mr. George Munakango の自宅へ行き同乗してもらう。9:41 発

10:08　Sinamalima 着　灌漑組合の事務所で情報収集後、カリバ湖岸へ。近年カリバ湖の水位低下のため湖岸が２ｋｍ前進し、干上がった湖岸で野菜栽培が行われていた。

11:10　Sinamalima 発 Sinazese へ戻る (11:38)

11:50　Nkandabbwe irrigation scheme（鉱山で採掘中水脈に当たってしまい溜池になり鉱山は閉鎖）

12:45　Sinazongwe で昼食

13:30　District Agricultural Coordinator (DACO)の Mr. George Samiaamba から情報収集
Sinazongwe の降水量は　950mm (2003/4), 251mm (2004/5)

14:40　Zambeef の気象ステーションの情報を得るため見学（結局機能していないことが分かる）

15:53　Zambeef 発 Sinazese を経由して

17:29　Choma（給油）-Kozo Lodge 着

８月７日（日）チョマ～リビングストン

8:41　Kozo Lodge 発

10:36　Livingstone 着　Wasawange Lodge (83USD/night)

12:05　WaterFront で昼食

14:30　Zimbabwe との国境

20:00　Wasawange Lodge

８月８日（月）リビングストン～ルサカ

8:52　Wasawange Lodge 発
Choma の PACO が言っていた Provincial Centre for GIS を探すが見つからず、Survey Department, Mr. Kabue が Cabinet Office に居ることが分かったが時間不足のため今回はあきらめる。

9:48　Livingstone 発（給油）

11:40　Choma-PACO を訪ね先週のお礼と報告をする。Southern Lodge で昼食

13:25　Choma 発

15:09　Mazabuka（給油）

17:29　Lusaka-Arcade

18:45　Juls 着

８月９日（火）ルサカ～ペタウケ～チパタ

7:15　Juls 発 途中１２月と同じ場所、同じ理由で車を３０分止められるが通してもらう。

10:25　Luangwa River; 途中ドライバーの免許証コピーが読めないためポリスに何度か止められる。Kacholola (11:17); Nyimba (11:30)

12:16　Petauke junction-宿泊する予定だった（予約は入っていなかった）Nyika Motel で昼食
13:20　Petauke-Weather Station を見学
14:00　DACO を待つがなかなか来ないので Department of Agriculture の Mr. Friday Sikombe に合い情報収集する。Petauke District の SEA がどこなのかを聞き出す。DACO の前に PACO に会うことを勧められたので Chipata へ向かう。
15:00　Petauke junction で給油
16:08　Katete
17:24　Chipata-Chipata Municipal Motel (50,000ZK/night)

８月１０日（水）チパタ～ミンガ～ルサカ
7:15　Chipata Motel 発　市内のマーケットを見学後、出発　(7:50)
9:10　Katete（吉川さん調査地の Kaliza 村訪問は今回は時間不足のため断念）
10:00　Petauke junction で給油
10:15　Minga-幹線から 4km 離れた Minga Mission を訪ね情報収集
11:43　Minga 発
12:20　Niymba-Food Palace で昼食
14:20　Luangwa bridge
15:10　Rufunsa
16:24　Chongwe
16:55　Lusaka-Arcade で e-mail
18:00　Juls 着

８月１１日（木）ルサカ市内
8:40　Juls 発
8:55　梅 津 ― Central Statistical Office, 佐 伯 ― Meteorological Department, 吉 村 ― Survey Department の 3 ヶ所に分かれて情報収集。
11:10　FAO で Mr.Daka に頼んでいた資料のコピーを受け取る
11:40　Dong Fang Restaurant （東方飯店）で昼食
13:30　Department of Geomatic Engineering, University of Zambia へ Mr.Mwanza を訪ねるが不在
13:45　Institute of Social and Economic Research へ Mr. Mulenga を訪ねるが不在
14:35　Department of Geomatic Engineering へ再度 Mr.Mwanza を訪ねるが不在
15:00　Lusaka 市内で shopping
16:27　Juls 着―夕方レンタカーと Guest House の支払い(USD)

８月１２日（金）Juls 発(5:45) 空港着(6:10) ルサカ発(7:55 SA69) ヨハネスブルグ着(10:00)
ヨハネスブルグ発(14:10 EK762)
８月１３日（土）ドバイ着 (00:20)ドバイ発(2:50 EK316) 関空着(17:20)

２．聞き取り情報等

Aug.3　Dr. Mulengaとのミーティング

―Chipata を含む南部ではここ１０－１５年間、降水量が少ない

―北部はインフラ整備が遅れており、低開発のままである。

―Zambia の Agro-ecological Region (Region I<800mm; Region IIa, IIb 800-1000mm; RegionIII >1000mm) Region III の土地は鉄分不足の熱帯性土壌；

―南部の Region II では商業的農業が行われている。Plateau ではタバコ栽培；　Escarpment ではカリバダムの建設により移住が行われた。以前は２期作が行われていたが、食糧不足のため近年 casaba 等が栽培されている。畜産も条件的には厳しい地域である。Sorghum は１９７０年代に病気の被害に会った。チョマでは土地不足が顕在している。多くの土地は商業的農業者が所有。農民は土地を求めて中部州へ移住している。９３/９４年頃から移住が多くなった。また Zimbabwe からも Zambia 南部へ移住する者が増えている。

―Petauke は Region　II であり、cotton, maize の産地。男性は conventional crop;　女性は food security を担っていたが、近年この役割が弱まり food insecurity となっている。

―Vulnerability Assessment は Min. of Agriculture/Meteorological Department 等

―SADIC(Southern Africa Development Community)は Early Warning System にも関与（？）

―Maize production の５０・６０年代の報告書は Elizabeth Colson によって書かれている。

Aug. 3　ザンビア気象庁訪問（梅津、吉村、佐伯）

Head office

Zambia Meteorological Department

Ministry of Communications and Transport

CHIEF　Mr. Jacob Nkomoki, Acting Deputy Director, Forecasting & Research Division

応対して下さった研究者:

Mr. Joseph Kanyanga, Acting Chief Meteorologist, Forecasting & Research Division

データがほしい時には、欲しいパラメータ、期間、ステーションを決めてくること。できれば、頼んでから数日間の期間をあけて取りにくること。

保有データのリストは見せてくれなかった or 作っていないらしい。

※ 気象ステーションは、全国で 63。南部では、Livingstone・Choma・Magoye など 4 つのステーションがオペレーショナル。また、ザンビアは、Z.A.B と S.L.M.(NITCZ)及び NLT(SITCZ)の気候帯に囲まれているために降雨量で区分されるよう になる。気象ステーションでの観測項目は、Cloud Cover/Temparature/Rain Fall/Evaporation/Valometer(AirPlesure)/Sunshine など

Aug.11 気象庁再訪問　（佐伯。途中から吉村、梅津合流）

Mr Kanyanga が office にいて、アポなしにも関わらず会うことができた。

Met.データについて

前日に書いた希望データの WORD ファイルを USB で渡す。Mr Kanyanga に WORD ファイルを書き直される（添付ファイル"ZambiaMetData.doc"参照）。こちらの希望は、「全３６ステーションについての可能な期間の monthly 降水量」であったが、「南ザンビア８ステーションのここ１０年の annual 降水量」に書き直された（8 ステーション＝CHIPAT, CHOMA, KAFUE, LIVING, LUSAKA01, LUSAKA02, MAGOYE, MTMAKU, PETAUK）。FS の段階では、これで十分だろうとのこと（つまり、もう一度来て買いなさいということか）。１０年間というのは、各ステーションのデータが consistent だと言える（保証できる）期間とのこと。Mr Kanyanga、WORD ファイルをプリントアウトし、私がサイン、Mr Kanyanga も余白に何か書いていた。これをもって１階のコンピュータルームへ。コンピュータルームの PC(Windows98)には、CD-R も USB インターフェイスもないので、持参のフロッピーディスクにコピーしてもらう。Mr Kanyanga がすぐにやってくれるよう指示してくれた。今回担当してくださった方は、

Computer Room / Mr. Boniface Mbewe,

この方が言うには、直接 computer room に来てデータを注文してもよいとのこと。値段は bytes 換算で決められる（添付資料"charges.doc"参照）。今回は、30,500KZ。現金払い。領収書は地球研の用紙に書いてもらい、スタンプもちゃんと押してくれた。

Early Warning Systemについて

Mr Kanyanga に聞いてみる。Ministry of Agriculture, Central Statistical Office, Disaster Management なんとか, Met. Dep. の４つが、いろいろなデータを集めて、話し合い、warning を出す。機械的なシステムというよりは、会議の方に重きがある。Mainly Human + (data & equipment)。

※ Met. Dep.の担当者: Mr. Francis Banda, Acting Agro-Meteorologist is the departmental representative to the national early warning unit.

Voluntaryなstationについて

Met. Dep で運用している 36stations の他に、voluntary のステーションがある。測定は、ほぼ rainfall だけ。これらのデータも Met. Dep に上がってくる。しかし、必要に応じてアドバイスをするだけで、Met. Dep のデータシステムには入れていない。主にハードコピー（紙）で保存している。

Met.station LUSAKA01 見学　（梅津、吉村合流）

２つある LUSAKA の station の１つ。Met. Dep の裏、Local 空港の脇にある。

Met. Dep. Webサイト： http://www.weather.co.zw/index.cfm

Aug 4　Dr. Jones Govereh とのミーティング（ＦＳＲＰ Office）

―代表の Jan Nijhoff 氏が休暇中のため Dr. Jones Govereh 氏と会い、Food Security Research Project の概要説明を受ける。Dr. Govereh は Zimbabwe 出身でＭＳＵ卒のエコノミスト。

―Central Statistical Office（CSO）では Crop Forecast Survey と Post Harvest Survey を実施している。

１．Crop Forecast Survey: 毎年４－６月実施、農産物生産量予測により政府が輸入・輸出のバラン

スシートを作成する資料とする。８０年代から行っている。
２．Post Harvest Survey: 毎年１０月実施、ザンビア全土で 8000 世帯について、National/Provincial のサーベイを行う。District level のデータは良くない。2000 年の PHS は新しいフレームワークで行う。各 district に３－５の SEA(Standard Enumeration Area)を設定し、20 households(HH)/SEA を調査する。
例えば Southern Province には 30 の SEA があり、各 SEA が 20HH を持つ。SEA はある期間同じ場所でも household は年によって違う。
―supplemental survey：FSRP では CSO と一緒に CSO の Provincial HQ staff を enumerator(調査員)として CSO が毎年行っている Post Harvest Survey (PHS) 8000 世帯のうち 2000 年に実施した同じ世帯 7500 世帯分の supplemental survey をザンビア全土で実施している。（実施年　2001, 2004）
調査内容は post-crop, other non-farm income など。
―CSO はデータ集めは行うが分析はあまり行っていない。
―FSRP の年間予算は 3.5million USD/year でそのうち supplemental survey は 1 回 0.5millionUSD.（５千万円程度）プロジェクトは 2007 年で終了するが、USAID の新しいプロジェクト MATEP(Marketing & Trade Enhancement Project)に一部吸収される予定（2010 年まで）
―2004/5 年の旱魃で南部州のメイズ生産が影響を受け、85,000 トン不足している。Cotton, tobacco はブームで生産量が伸びているが、メイズは作付面積が減少している。補助金が廃止され、農民が作付けを多様化したためである。コンゴのメイズ需要は伸びているが、ザンビアが輸出を規制するというちくはぐな政策がとられている。

Aug 5　Mr. Collins Nkatiko (Provincial Agricultural Coordinator)からの情報

―南部州のうち Siavonga, Gwembe, Sinazongwe, Kalomo Districts のカリバ湖岸は旱魃常習地帯であり、今年は 300-400mm しか雨が降らなかった。Region I に属する。
―農民の Coping strategy として１．カリバ湖での漁業、２．援助に頼っている。畜産もあるが最貧困層は家畜も所有していない。野生植物や NGO からの食糧に頼っている。
―Sinazongwe には４ヶ所の SEA (Sinazese, Kafamira, Maamba, Malima)がある。
―Gwembe は Region I (Valley)と Region II (Plateau)が含まれる。Valley の土壌は肥沃だが、plateau では疲弊している。
―近年カリバ湖の水位が低下し湖岸が 2 km 後退している。
―Provincial Centre for GIS が Livingstone（Cabinet Office - Mr. Kabue）にある。

Aug 6　Mr. George Samiaamba (Sinazongwe District Agricultural Coordinator)からの情報

―Sinazongwe の降水量は 2003/4 年は 950mm、2004/5 年は 251mm であった。2004 年の降雨予想は平年以上ということだった。
―８０－９０％の農作物が収穫できなかった。Sourghum, millet, maize, cowpea のうち特に Sourghum, millet, maize の被害が大きかった。Malima (SEA)では現金作物の cotton が被害に会った。
―過去の例では、９２年はそれほどひどくなかったが、94/95 年は大旱魃で農作物の 100%が被害を受けた。
―Disaster Management & Mitigation Unit/Office of the President が旱魃の被害を受けた５－６万世帯

へ年４－５月ころまで１００トンの食糧配給をする。この地域のメイズとソルガムの栽培面積比は約２：１である。今年の作付け期（１２月）に農家は種子がないので、支援プログラムとしてメイズ種子と肥料を配給する。
―貧窮時の食糧として地元で使われているのは　Masao (fruit tree), bushika (tamarindo tree), zunkura (山芋), inji, 雨季には蟻、masenda (白い幼虫)、dried kapenta（小魚）
―この地域の農民はほとんど自家消費用の農作物を生産するのみであり、売るための農産物は生産していない。
―District Agricultural Coordination Office の仕事は 1. Crop Forcast,と 2. Post Harvest Survey の実施。

Aug 9　Petauke District Agricultural Coordination Office での情報聴取

Mr. Friday Sikombe (Head, Agriculture), Mr. Muale (PHS の担当者)に会い情報収集。
―Petauke District の SEA は 1.Niyanji(Kapoche block), 2.Nyamphande, 3.Minga, 4.Ukwimi.
―今年の作物被害は８５％。土壌保全農業を実施した農地の農作物のみが収穫できた。
Conservation farming の内容は、ditches （畝）and basins (pit 農法？)
―Chipata の Provincial Agricultural Coordinator にまず会う様に勧められたが、時間不足のため断念する。

Aug 10　Minga Mission

Petauke District の SEA の一つである Minga を訪ね、Minga Mission の小学校と高校で情報収集。
―１９２３年に Missionary of Africa が教会、病院、学校を建設する。現在は病院のみが Kilimanjaro Sisters (Tanzania)により運営されている。
―８月は夏休み。旱魃の影響で食事を満足にしてこない生徒が多い。（小学校）
―３０－４０％の学生が授業料（１学期　11,000ZK）を支払えないでいる（高校）
―地元の住民は今年は農作物が取れなかったので近くの森に roots crop, yam, wild cassava を取りに入っている。１１月にはグリーン・マンゴーを収穫し、食糧にする予定。
―１１月にメイズ、groundnuts, cotton（月末）の播種をし、１２月の最初の雨を待つ。収穫は４月（メイズ)、５月（groundnuts)、６月末（cotton）
―土壌は貧弱で肥料を購入する資金がないため、養分不足
―１０村あるが、bore well は全くない。今年は飲料水の確保にも窮している。
―ルサカへの帰路、Nyimba でメイズの買い付け業者に会う。農家からの買い付け価格は 620ZK/kg(maize grain)。Milmeal (Shima 用に粉にしたもの)の価格はマーケットで 1500ZK/kg.

Aug 11　Survey Department 訪問（吉村）9:10～10:15

Mulungushi House, Agency of Land 2 階
面会者：
Danny Mubanga (Survey-general)
Bwalya N. Chuba (Head of Photogrammetry)
Mooka(Chief of Cartographer)

・ザンビアの地形図に関する情報

1) ザンビアの測地系は、UTM が採用されており、34 ゾーンから 36 ゾーンの 3 つのゾーンに属す。
2) 国土基本図は、5 万分の 1 で全土を 826 枚でカバーする。
3) 紙地図のデジタル化については、Northern Province と Western Province、並びに 5 つの District で作業が完了している。全体の 40%に相当する領域。
4) デジタル地図(ベクトル地図)については、ルサカ市内に限って整備されている。それ以外では、ダム建設などの特別な場合に限って作成されることがある。
5) 地図作成のための航空写真撮影については、1990 年にヨーロッパから航空機をチャーターし全土的に実施され、それ以降 1991 年からは Up to Date。
6) ディジタルデータについては、Survey Dept.にサーバーを設置し、Internet で結び、地方とのデータ流通を図る計画がある。Ndola と Living Stone でのみ設置が完了している。

・ 今後の関係について

1) 航空写真および地形図については、今回面会した 3 名が責任者にあたる。したがって、こちらの方針が決まり次第、担当者に連絡を取り、今後の対応について検討してもらうことをお願いした。

・ その他

1) 同国のリモートセンシングについては、National Remote Sensing Center が分担しており、こちらの情報については、今後要対応。

2) Choma で話しを聞いた Livingstone にある Provincial Center for GIS のデータは、ルサカにある同局と LAN で接続されデータ提供がなされている。

Aug 11　Central Statistical Office (梅津)

Mr. Masiliso Sooka (Head, Agriculture)と Mr. Colby S. Nyasulu (Post Harvest Survey)に会い情報収集。PHS の SEA リストを提供していただき、その地図も e-mail で送ってもらう様交渉する。今回入手したのは、以下の 4 provinces 5 districts)。地図はすでに入手済み。

1. Southern Porvince (Choma, Sinazongwe districts)
2. Eastern Province (Petauke district)
3. Lusaka Province (Luangwa district: vulnerability assessment で highly　vulnerable と評価されている Zimbabwe, Mozambique 国境)
4. Central Province (Kabwe district: 島田先生の調査地の近く)

―ＳＥＡはある一定期間(2000, 2002, 2003, 2004)は同じ場所で行われたが、調査家計は年ごとに異なっている。（そのため FSRP の supplementary survey では 2000 年の調査と同じ家計に戻りインタビューを行っている）

３．入手資料 Reports and documents collected in August 2005 Zambia Field Trip (1-13 August, 2005)

[Central Statistical Office]

Published reports

Living Conditions Monitoring Survey Report 2002-2003, Central Statistical Office, November 2004.

Zambia HIV/AIDS Epidemiological Projections 1985-2010, Central Statistical Office, January 2005.

Zambia 2000 Census of Population and Housing: Census Atlas, Central Statistical Office, November 2003.

Zambia 2000 Census of Population and Housing: Analytical Report, Central Statistical Office, 2004. (Volume One Central Province; Volume Three Eastern Province; Volume Five Lusaka Province; Volume Eight Southern Province)

Zambia 2000 Census of Population and Housing: Agriculture Analytical Report, Central Statistical Office, November 2003.

Selected Social Economic Indicators 2000-2003, Central Statistical Office, November 2004.

2000 Census Reports Chapter 1-9 [pdf files]

2000 Census of Population and Housing: Census Atlas [pdf file]

2000 Census of Population and Housing: Summary Report2 [pdf file]

2000 Census of Population and Housing: Agriculture Analytical Report [pdf file]

2000 Census of Population and Housing: Housing and Household Characteristics-Analytical Report [pdf file]

2000 Census of Population and Housing: Migration and Urbnization 2000 Census Report [pdf file]

Living Conditions Monitoring Survey (LCMS2) 1998 questionnaire [pdf file]

Living Conditions Monitoring Survey II (LCMS) 1998 Supervisors' Instruction Manual [pdf file]

Zambia Demographic and Health Survey 2001-2002, Central Statistical Office, February 2003 [pdf file]

The Food Security, Health and Nutrition Information System (FHANIS) August 2003, Central Statistical Office, November 2003. [pdf file]

Living Conditions Monitoring Survey – I 1996, Central Statistical Office, 1997?. [pdf file]

Rural Income and Livelihoods Survey 2004 - Second supplemental Survey to the 1999/2000 Post Harvest Survey (for small and medium scale holdings), Central Statistical Office. pp.1-33. [questionnaire, pdf file]

Zambia Sexual Behaviour Survey 2003, Central Statistical Office, Ministry of Health, Measure Evaluation, March 2004 [pdf file]

Unpublished materials

List of SEA (Standard Enumeration Area): Central, Eastern, Lusaka, Southern Provinces

Map of PHS (Post Harvest Survey) study areas: Central, Eastern, Lusaka, Southern Provinces

[digital map]

Publication List (Sales & Dissemination Office)

[Meteorology Department]

Republic of Zambia Agroecological Zones [Word file]

Summary on the Rainfall Performance of the 2004/2005 Growing Season, Weather Monitor, The Director of Meteorology, Ministry of Communication and Transport, Lusaka. [Word file]

Rainfall data: Type: Recorded Annual rainfall (mm) [digital]
Location: Lusaka, Choma, L/stone, Kafue Polder, Mt. Makulu, Magoye, Petauke & Chipata. stations
Period: 1994 -2004

Met station の位置データ:（帰国後 e-mail で入手）

[Ministry of Lands/Survey Department]

Vegetation Map of Solwezi District	Scale: 1: 500,000
Mtwara Development Corridor Map	Scale: 1: 1,200,000
SE-35-4 KARIBA	Scale: 1: 250,000 (published 1974)
SD-36-9 PETAUKE	Scale: 1: 250,000 (published 1973)

[Food Security Research Project (USAID/MSU)]

various papers are downloadable at http://www.aec.msu.edu/agecon/fs2/zambia/index.htm

[FAO]

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平成17年度1－3FS（梅津FS）研究活動一覧												
FY 2005	4	5	6	7	8	9	10	11	12	1	2	3
FS研究会	13:00-17:00		9:30-12:30	13:00-17:15			11:00-17:30	13:00-17:30	13:00-17:00			
及びミーティング	4月28日		6月10日	7月21日			10月21日	11月25日	12月9日			
（レジリアンス研究会	（第7回）		（第8回）	（第9回）			（第10回）	（第11回）				
フィールド調査					ザンビア・フィールド調査							
FS報告書										FS報告書完成	2月末製本	
PR申請書									PR申請書提出			
FS関連行事	FSヒアリング					（FSヒアリング）		FS勉強会	研究発表会	PR 予算提出		評価委員会
	4月4日					9月21日		11月4日	12月14日			ヒアリング
	地球研							地球研	ロープイン京都			3月2-3日
												地球研
地球研行事							プレシンポ		FS勉強会		上賀茂へ移転	
							11月18-20日		12月3日		2月11-15日	
							ぱるるプラザ		地球研			
フィールド調査日程												
					Zambia		Bonn: IHDP	Zambia				
梅津					8/1-8/13		10/9-10/13	11/1-11/17		（India）		
								Zambia				
櫻井								11/1-11/17				
					Zambia							
佐伯					8/1-8/13							
								Zambia				
島田								11/11-12/13				
							Zambia					
真常							10/26-11/12					
							Zambia					
田中							10/30-11/25					
							Zambia					
宮崎							10/26-11/17					
					Zambia							
吉村					8/1-8/13							
										India		
久米										1/16-22		

Vulnerability and Resilience of Social-Ecological Systems – FY2005 FS Project Report

Project 1-3FS

Project Leader: Chieko Umetsu

February 2006

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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１７年度 FS 研究プロジェクト報告

プロジェクト１－3FS

プロジェクトリーダー　梅津　千恵子

2006 年 2 月

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