

climate zone. The long term averaged annual rainfall in Sinazongwe is 695mm/yr.

As for the field investigation, we set the study sites A, B and C where are located in the lower terrace, middle escarpment and upper terrace, respectively. This is the common study sites for our research project; thus many rain-gauges were installed at Sites A, B and C. The targets of field survey are total five villages; Siameja and Sianemba (Site A), Kanego and Chanzika (Site B) and Siachaya (Site C).

3. MULTI-DISCIPLINARY FIELD RESEARCHES FOR UNDERSTANDING VILLAGE LEVEL'S LIVELIHOODS

To understand the livelihoods in village level, we have carried out the field investigations from multi-disciplinary point of view. The main livelihood is agriculture to keep their food. They also have other livelihoods to earn cash income.

3.1 Agricultural activities

The crop field distribution at the village level for one year shows household's activities related to people's livelihoods. In this study, the crop allocation map was generated to understand people's livelihoods from year to year.

Field investigations for crop allocation mapping were carried out for 195 households in the Sianemba, Sianemeja (Site A), Kanego, Chanzika (Site B) and Siachaya (Site C) villages during the rainy season of 2007/2008 and the dry season of 2008.

To build up the crop allocation map, we used a portable GPS to measure boundaries at a sub-field level that recognized different crops at Sites A, B and C. We also carried out interviews about field names, topography, soil name, crops, cultivated varieties and kinds of fertilizer with all households to understand their coping strategies related to climate variations. Table 1 sets out the classification code and its description as attribute information to the crop allocation map, which shows the crop field boundaries and the attribute information in the GIS data format.

Also, we recorded the crop field which was damaged by natural disaster such as drought or flood and which kind of crops they replanted after damage.

Table 1. Crop field classification and its description

Code	Discription about crop field
RCo	Rainy season /Cowpea
RC	Rainy season /Cotton
RFm	Rainy season/ Finger Millet
RG	Rainy season/ Garden
RGn	Rainy season/ Groundnut
RM	Rainy season/ Maize
RO	Rainy season/ Other
RS	Rainy season/ Sweet Potato
RSf	Rainy season/ Sunflower
RSo	Rainy season/ Sorghum
Rsu	Rainy season/ Suger cane
DG	Dry season/ Garden
DM	Dry season/ Maize
DSu	Dry season/ Suger cane
RFa	Falow in rainy season

3.2 Other livelihood (Non-agricultural activities)

Each household has other livelihoods with the exception of agricultural activities for cash income such as selling maize, cotton, vegetables and livestock, fisher and piece-work etc. These kinds of activities are different in each target village.

We have had interviews about the ratio of cash income in non-agricultural activities for all households in sites A, B and C in 2007 and 2008.

We have also investigated human networks in study sites. There are kin networks, neighbourhood networks, religious networks, scholastic networks, networks in recreation, and networks in activities earning income.

3.3 Temporal and Spatial data analysis

To generate the Digital Elevation Model (DEM) and the large scale topographical map of our study area, Sites A, B and C, we obtained aerial photographs archived by the Survey Department of Zambia. Aerial photos had been taken after the independence at a scale of about 1: 30,000 in 1965, 1970, 1980 and 1991. However, the 1965 photos did not include our study area. Thus we were able to use aerial photographs taken in 1970 (90sheets), 1980 (67sheets) and 1991 (72sheets). Figure 2 shows a sample DEM with 2.5m grid and an Ortho aerial photo generated by one stereo pair around the middle of Sites B and C. From the aerial photographs, we can detail and analyze the terrain features by DEM and so generate detailed topographical maps at a scale of about 1:10,000. We use also ASTER GDEM with 30m grid for terrain analysis at middle scale.

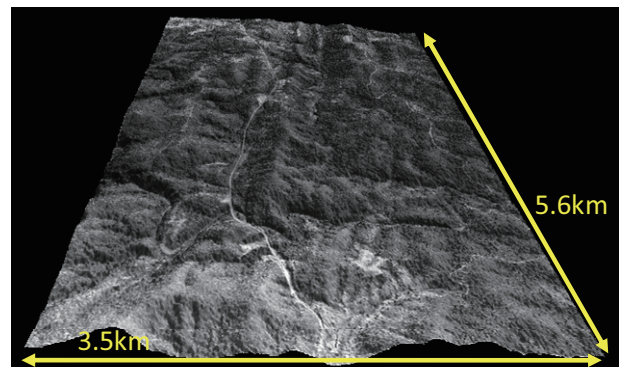


Figure 2. A sample of ortho photographs overlaid to DEM with 2.5m grid

As for the multi-temporal data, we obtained satellite images taken with an optical sensor at middle-high and high resolutions to identify crop field distributions and land surface conditions reflecting seasonal and inter-annual changes. More than 30 imageries of Landsat series, Terra/ASTER, ALOS/AVNIR-2 and ALOS/PRISM have been obtained so far.

We can analyze the relationship between crop field distribution and terrain conditions by using those kinds of temporal and spatial data.

4. RESULTS OF FIELD RESERCHES

4.1 Crop distributions in rainy season of 2007/2008

Figure 3 shows the crop allocation map in rainy season of 2007/2008. The background of figure is ALOS/PRISM image. The characteristics of the crop field location were different in each study site. Almost crop fields distributed mainly along the mountain ridges and the gentle slope of hill in site C. Crop

fields in site B distributed around the very steep slope of hills. The terrain in site A is basically flat, and the soil is more fertile than site B and C.

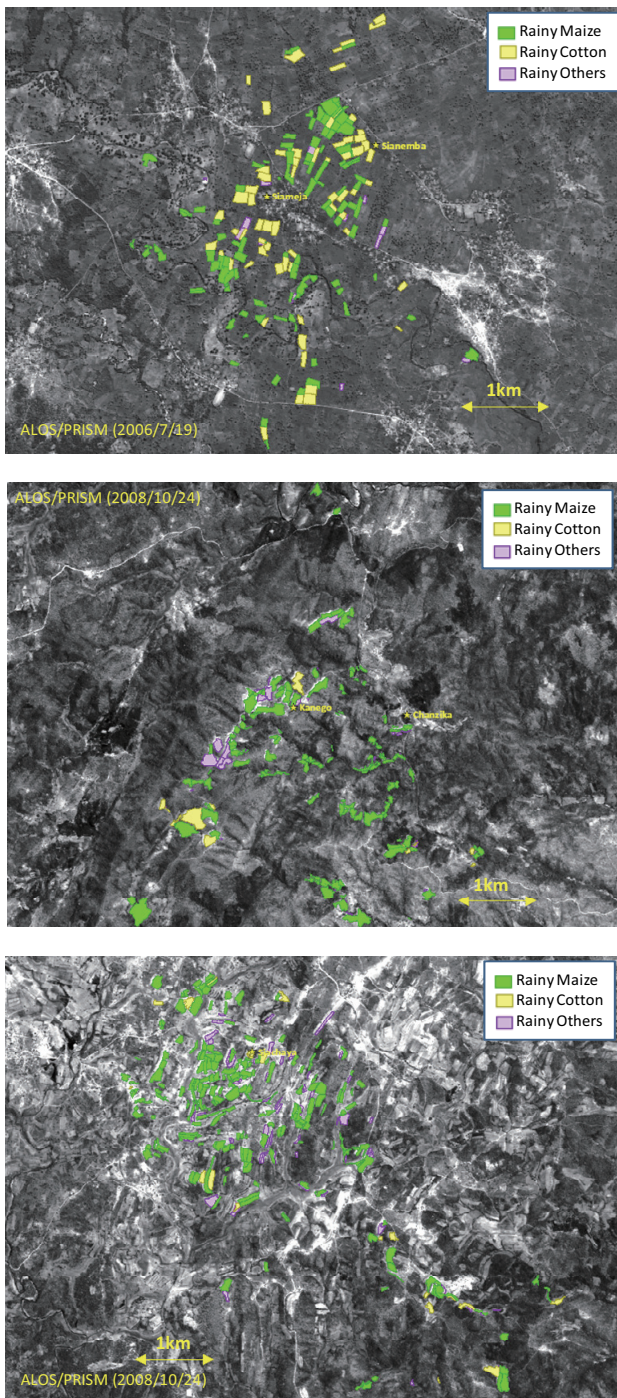


Figure 3. Crop fields distribution in site A (upper), B (middle) and C (lower)

Figure 4 illustrates the graphs of each rainy crop field area in ratio for each village. Total rainy crop field area in hectare is also shown. Cotton of cash crop occupies about 40% in two villages of site A. Therefore, ratio of maize is lower than site B and C. The crops in Kanego (B) are variable, however in Chanzika (B), maize field occupies more than 90%. Main crop except maize is sweet potato in Siachaya (C). Sweet potato is cultivated in only site C. The difference of crops in each village might be related to the terrain characteristics and soil conditions.

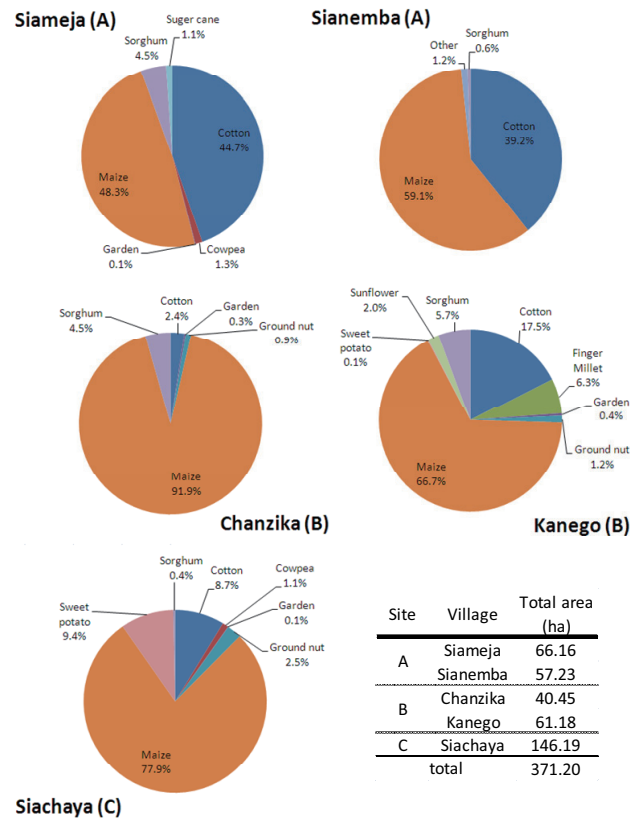


Figure 4. The ratio of crops fields area in each village

4.2 Non-agricultural activities for cash income in 2007 and 2008

We confirmed that the ways to get cash by non-agricultural activities were different in three sites. Basically, the common ways were selling livestock and maize. Selling cotton and piece work were mainly occupied in site A. Selling planks and poultry were occupied in site B and C respectively. The characteristics of other livelihoods depend on accessibility to natural resources. Also, the ways of cash income had changed from 2007 to 2008.

5. CONSIDERATION OF COPING BEHAVIOR FOR LOCAL LEVEL CLIMATE

In the rainy season of 2007/2008, our study site had a heavy rain and many crop fields were damaged. In this crop year, the annual rainfalls in site A and C were 1442mm/yr and 1332mm/yr respectively. This is about 2 times of long term average of rainfall 694.9 mm/yr in Sinazongwe district. Here, we have analyzed how the villagers cope with serious damage to crops from heavy rain by data integration of multidisciplinary researches.

5.1 Coping to flood damages by agricultural activities

According to the area totalization from the crop allocation map, about 20% areas of all maize fields in our study Site A, B and C were damaged from heavy rain. As for the every site, the ratios of damaged area in total crop fields area were 34%, 28% and 4% in Site A, B and C respectively. There are the differences among three sites. It is supposed that the topographic differences are affected. From GIS analysis of the damaged fields during 2007/2008 rainy season, flood damages are

concentrated in ill-drained fields in Site A lower terrace, steep fields in Site B mid-escarpment, and valley bottom fields in Site C upper terrace by using DEM and ortho photos. Figure 5 shows the damaged field's distribution in site C overlaid to the topographic map of 1:50000 and ASTER GDEM with shading. We can confirm that the damaged crop fields are along of the valleys and rivers.

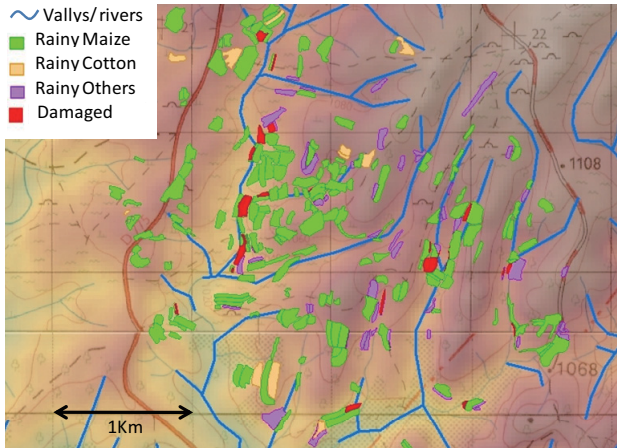


Figure 5. Damaged fields by heavy rain in case of site C

Figure 6 shows coping after the flood damages in each village.

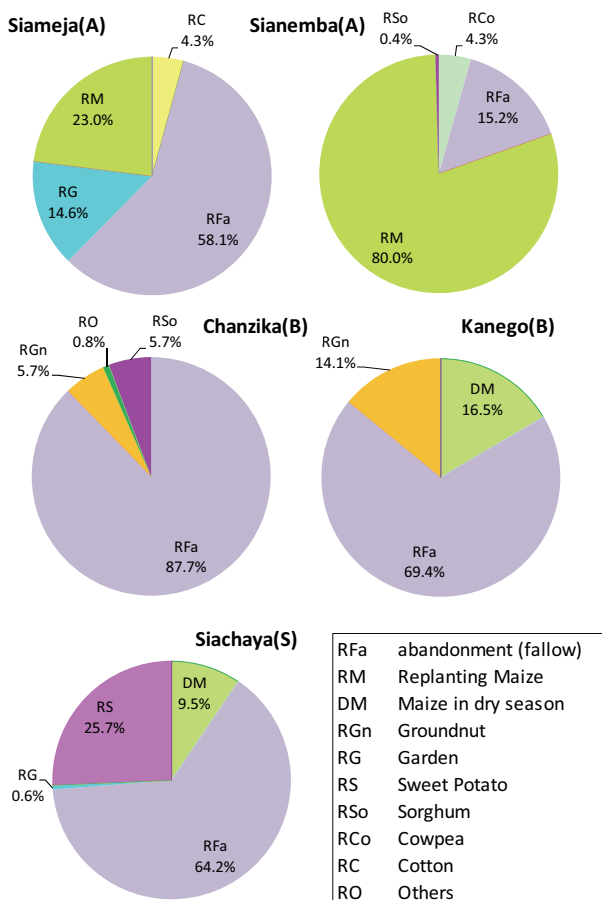


Figure 6. The ratios of coping after flood damage in each village

As for the coping to flood damages, about 60% of all damaged fields were abandoned and the other fields were replanted as

crop field after damage. 80% of damaged fields were planted maize again in Sianemba (site A). Contrastingly, 26% of damaged fields were planted sweet potato in Site C. In site B, almost damaged fields were abandoned, and some fields were replanted by groundnut. We could understand that the coping behaviour for heavy rain was different in each site.

5.2 Coping to flood damages by non-agricultural activities

We also considered the area of damaged fields for each household in site A. There had the biggest damage by flood in our study sites. The ratio of households of which more than 80% fields were damaged was about 20% in site A. Accordingly we compared the cash income situations in 2007 and 2008 for those households (table 2). The values in table indicate the engaged ratio to total cash income at each household.

Table 2. Cash income situations at the households which had more than 80% damaged crop fields

income in 2007	animals	maize	cotton	vegetable	gathering	fish	bar	carpenter	piece work	others
Asm11		30.0	20.0	30.0			20.0			
Asm27		50.0			20.0					30.0
Asn8		50.0						20.0		30.0
Asn16		20.0							80.0	
Asn18		5.0	90.0						5.0	
Asn29		50.0	40.0						10.0	
Asn37		50.0							50.0	
↓ decrease										
income in 2008	animals	maize	cotton	vegetable	gathering	fish	bar	carpenter	piece work	others
Asm11	50.0									50.0
Asm27		25.0							30.0	45.0
Asn8			80.0	20.0						
Asn16						75.0			100.0	
Asn18									25.0	
Asn29	40.0		20.0							40.0
Asn37									100.0	
Asn38	20.0					80.0				

In 2007, those households got cash by selling maize and cotton mainly. However, the way to get the income was changed to selling domestic animals, fisher and piece work (marking yellow) instead of selling maize in 2008. This is also one of the coping strategies by non-agricultural activities.

In near future, we will clarify other coping behaviours by giving and receiving of food and labour force in kin and neighbours networks.

6. CONCLUSION

In this study, we have carried out the field investigations and geo-spatial analysis related to the village level's livelihoods by the multi-disciplinary approach. Through the integration of various data, we could understand the coping behaviours for flood damages and those properties at household level in three different terrains of our study sites.

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