Analysis of Impact of Heavy Rainfall Shocks on Time Allocation Changes in Rural Zambia

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Abstract

This paper examines the effect of rainfall variability on people's time allocation using weekly household survey data sourced from rural Zambia. The data collection period was November 2007 to November 2009, during which an extremely heavy rainfall occurred. Changes in time allocation are examined among various activities using time use data from a weekly household survey. The data show that people worked longer hours after the heavy rainfall. These results were robust for activity categories, gender, and comparisons between children and adults.

1. Introduction

Labor supply is considered to be one of the many coping strategies employed after a shocking event. For example, Rose (2001) analyzed off-farm labor supply for agricultural households under risk of unusual rainfall in India, and showed that households with greater reliance on rainfall (i.e., with greater risk) were more likely to participate in the labor market (*ex ante* response). In addition, that study showed that unexpected low rainfall also increased labor market participation (*ex post* response). Further, Beegle et al. (2006) used data from a household panel survey in Tanzania and that found that disasters resulted in income shocks to agricultural households and significantly increased the incidence of child labor. However, previous studies have generally only conducted before-and-after comparisons of shock events to capture its impact, because of the limited availability of long-term time use data. In contrast, the household survey from the Resilience Project provides us with a high-frequency panel data covering a two-year period (this period is long enough to capture fluctuations in labor supply). With the use of this dataset, this paper examines the effects of a heavy rainfall shock in December 2007 on households' time allocation. Specifically, we focus on labor activities.

2. Data

In this study we used data (from to November 2007 to November 2009) collected in the above-mentioned household survey. The survey (which is ongoing) was initiated in November 2007 in three ecologically distinct sites located on the banks of Lake Kariba, as part of RIHN's Resilience Project (Sakurai, 2009 and Sakurai et al., 2010). One component of the household survey was a weekly interview regarding the allocation of each household member's daily time use over the past week. Thus, the dataset was collated to form individual-level weekly panel data for the two-year period, although there is some imbalance because of, for example, emigration,

immigration, births and deaths. Unfortunately, the dataset is too detailed to conduct any panel data analysis presently. Instead, we will conduct descriptive analyses.

Another important feature of our data is that it includes daily rainfall data recorded on the land plot of each sample household. As such, we have the same number of daily rainfall variations as we do sample households. However, for the descriptive analyses in this paper, we will use the difference in average rainfall between only two of the three ecologically distinct study sites: site A located in the low-lying areas of Lake Kariba and site B located on an escarpment between Lake Kariba and the Zambian plateau.

It has been reported that the study sites experienced an extremely heavy rainfall during the 2007 rainy season and that it severely damaged agricultural crops, particularly in site A. This event is confirmed by our rainfall data collected from the farmers' fields—monthly precipitation in site A was on average 100 mm higher than in site B for December 2007. Thus, this paper examines how people varied the allocation of their time use in response to the heavy rain shock. Taking advantage of the data structure we will conduct an intertemporal comparison within the fixed area, as well as, a cross-sectional comparison using fixed time. Moreover, the samples will be classified as either male and female or adults and children to control for variable characteristics.

3. Characteristics of Individuals

Of the activities that may be affected by the heavy rain shock, we are particularly interested in children's education and non-agricultural activities. Therefore, we will first summarize the characteristics of the individuals from the sample households using a baseline survey conducted with the first weekly interviews in November 2007. Similar surveys were also conducted in November 2008 and November 2009. The results of each survey are not identical because household members changed during the survey period, but we are able to confirm that on average central characteristics remained similar. The 2007 survey was employed as baseline data in this paper.

3.1. School Attendance and Education Level

From the baseline survey, we are able to classify all individuals residing at the sample households as of October 2007 into those who are and are not currently attending school. Although this question was asked of all individuals regardless of his/her age, we have only analyzed school-aged individuals of between 6 and 18 years of age.

Tables 1 and 2 summarize the classification of children by the status of formal school attendance for sites A and B, respectively. Children from each site are further classified by sex and age. Among primary school children (6–12 years of age) school enrollment rates are at 62% in site A and 56% in site B, while for secondary school children (13–18 years of age) it is 86% for site A and 100% for site B. In both sites the current enrollment rates are higher among secondary school age children than among primary school age children, particularly in site B where the latter is 100%. This result may appear surprising but the reality is that many children in the study sites delay starting school and most secondary school age children still attend primary school.

Nonetheless, the results indicate that enrollment rates are relatively high in the study sites. In addition, the rates are not significantly different because statistical tests for inequality in enrollment rates for the two sites cannot be rejected for either primary school or secondary school age children.

With regard to gender difference, enrollment rates for all children are 68% for male children and 72% for female, with primary age children at 59% for males and 57% for females. Neither result is statistically significantly different according to statistical tests for inequality in enrollment rates.

Table 3 shows the education levels attained by adults (18 years of age and over) in sites A and B. In Site B, approximately 40% of people have not received any formal education. In contrast, adults with no formal education is only 10% in site A, much lower than in site B. Furthermore, the majority of educated people completed grades 4–7 in site A, but site B adults attained lower grades on average. As shown in Table 4, the average years of education for adults is significantly higher in site A than in site B.

With respect to gender, differences between education levels are not so obvious in Table 4. Although male adults received on average more years of education (4 years) than females (3.1 years), the difference is not statistically significant. If the test is conducted for sites A and B separately, the results are the same: no gender difference in education is found (not shown in Table 4). Thus, we can conclude that in the study sites there is no gender difference in schooling with regard to both school age children and adults. Interestingly, education levels may be improving, as the current enrollment rate is very high even though there are illiterate adults in the study sites.

Table 1 : Formal school attendance (Site A)

	age 6-12			age 13-18			
	male	female	Total	male	female	Total	Total
yes	8	5	13	8	4	12	25
no	4	4	8	2	0	2	10
Total	12	9	21	10	4	14	35

Table 2 : Formal school attendance (Site B)

	age 6-12			age 13-18			
	male	female	Total	male	female	Total	Total
yes	8	7	15	3	7	10	25
no	7	5	12	0	0	0	12
Total	15	12	27	3	7	10	37

Table 3 : Education level (age over 18)

	Site A			Site B		
	male	female	Total	male	female	Total
None	1	3	4	8	10	18
Sub-standard A or B; Grade 1	0	2	2	2	2	4
Standard 1; Grade 2	1	0	1	2	0	2
Standard 2; Grade 3	1	0	1	2	1	3
Standard 3; Grade 4	2	7	9	1	2	3
Standard 4; Grade 5	2	2	4	1	1	2
Standard 5; Grade 6	1	2	3	3	1	4
Standard 6; Grade 7	5	3	8	3	0	3
Standard 7; Grade 8	0	0	0	0	1	1
Standard 8; Grade 9	5	2	7	0	1	1
Standard 9; Grade 10	0	0	0	0	0	0
Standard 10; Grade 11	0	0	0	1	0	1
Total	18	21	39	23	19	42

Table 4: Comparison of Average Years of Education by Site and Gender[1]

Classification	Site		Gender	
Group	Site A	Site B	Male	Female
Mean (S.D.)	4.7 (2.8)	2.6 (2.8)	4.0 (3.0)	3.1 (3.0)
Number of Obs.	45	51	51	45
t value	3.76		1.39	
Significance	0.00		0.17	

[1] t-values are based on two-sample t-test with equal variances.

3.2. Occupation

The baseline survey conducted in November 2007 asked all individuals residing at the sample households to list primary and secondary (if any) occupations, including those of school age and pre-school age children. In this section, occupations for adults (18 years of age and older) are summarized for each site in Tables 5 and 6.

In both sites A and B, agriculture is the primary occupation for virtually all adults, both male and female, as shown in Table 5. There are those that are employed in an agricultural primary occupation in site B, but they live separately from the sample households and do not appear in Table 5. In addition, there are some who are self-employed in non-agricultural positions. In addition, several respondents in site A are students. Students that are living in the study site are high school students, because no higher level of schooling exists within commutable distance. The baseline survey shows that two-thirds to three-quarters of adults do not have any secondary occupations, including those who refer to agricultural or domestic work as their secondary occupation. This result indicates that there is little diversification among income sources within the

study sites. However, six adults in site A and 16 in site B reported that they engage in non-agricultural, self-employed activities. Gender and site-wise, males in site B are most likely to have non-agricultural jobs. The most popular job for these males is logging in forested areas, which are found in site B.

Table 5 : Primary Occupation (age over 18)

	Site A			Site B		
	male	female	Total	male	female	Total
agriculture	16	22	38	23	20	43
student	2	1	3	0	0	0
Total	18	23	41	23	20	43

Table 6 : Secondary Occupation (age over 18)

	Site A			Site B		
	male	female	Total	male	female	Total
no 2nd job	9	9	18	7	7	14
agriculture	2	5	7	0	4	4
non-agri. jobs, self-employment	4	2	6	13	3	16
employed in agricultural sector	1	0	1	1	0	1
employed in non-agricultural sector	2	0	2	0	0	0
domestic work/ helping household	0	6	6	1	6	7
student	0	1	1	0	0	0
Total	18	23	41	22	20	42

4. Time Allocation

4.1. Time Use Data

Time use data were obtained from the weekly household survey by asking individual household members how many hours they spent on any of the seven activity categories: agriculture (WAG), non-agriculture (WNG), domestic/home help (WHH), school (WED), social (WSC), natural resource collection (WNR), and stock grazing (WGR), with the sum of work hours recorded as total work time (WLT). All individuals from each sample household, including both adults and children, recorded their daily time use for a week. Thus, the time use data structure is on daily and individual levels. To investigate the relationship between rainfall and time use, this paper aggregated monthly data to obtain average work hours per day for each activity category with controls for differences in site, gender, and age. The results are presented using a series of graphs from Figures 1.1 to 4.8 at the end of this paper, where the vertical axis on the left indicates monthly precipitation (ml) and the vertical axis on the right indicates hours per day.

4.2. Differences between Sites A and B

In both sites WAG labor hours during the rainy season were longer in 2007/08 than in 2008/09, as shown in Figures 1.1 and 2.1. Thus, the heavy rainfall impacted on self-employed

labor activities. In addition, as expected, the impact was more significant in site A where the rainfall in December 2007 was higher. Because agricultural production was severely reduced after the heavy rain (these data are not shown in this paper), a return to self-employed labor was very low for the 2007/08 crop season, particularly in site A.

With regard to WNG, as presented in Figures 1.2 and 2.2, the monthly pattern corresponds with that for WAG. As discussed in Section 3.3, average hours spent in non-agricultural employment during the dry season were longer in site B where more adults were engaged in such activities. However, total hours per day were less than 1 hour on average for both sites, which is significantly smaller than the fluctuations in daily work hours for agriculture. In contrast, people in site A spent more hours in WGR activities than in site B, particularly during the dry season (Figures 1.7 and 2.7). As livestock is an important income source in addition to agriculture, the results show that site A depends more on livestock than on non-agricultural activities.

When we compare Figures 1.3 and 1.4, results show that hours spent in WHH activities fluctuate more in site A than in site B: in Site B, this pattern appears to be independent of rainfall, while in Site A (particularly for 2007/08) it moves almost counter-cyclically to hours of WAG labor. However, in 2008/09, this relationship between WHH and WAG disappeared in site A. Thus, the counter-cyclical movement of WHH and WAG can be regarded as an impact of the heavy rain shock.

Despite both the complementary and counter-cyclical fluctuations of work hours among activities during the rainy season of 2007/08, WTL hours in both sites is greater for 2007/08 than for 2008/09, as shown in Figures 1.8 and 2.8. This difference is more significant in site A where the December 2007 rainfall was much heavier than in site B. WTL in site A is greater even in the 2008/09 rainy season. Therefore, this significant difference in working hours during the 2007/08 rainy season can be attributed in part to the basic difference observed between the two sites in normal years. A further explanation for this difference could be the longer working hours for WHH in site A than in site B as shown in Figures 1.3 and 1.4.

4.3. Gender Differences

In this section, we will examine whether the heavy rainfall had a differential impact on gender. Figures 3.1 and 4.2 show average daily working hours for WAG activities by gender for sites A and B. The graphs indicate that male WAG mirrors female WAG hours throughout the survey period: that is they are parallel. However, the difference between male and female daily working hours during the rainy season is significant in site B, while site A shows virtually no difference. This result indicates that adult males and females are equally engaged in WAG during the crop season in site A., because this tendency is observed for both 2007/08 and 2008/09, the disappearance of the male–female gap does not appear to be due to the heavy rain of 2007/08.

With regard to WNG, however, the working hours for males and females do not mirror each other so strongly, as shown in Figures 3.2 and 4.2. Furthermore, the gender gap exists both in sites A and B, indicating that males are more likely work in non-agricultural sectors during the dry season. WGR activities also appear to be performed by males during the dry season (Figures 3.7

and 4.7). In contrast, the opposite is always observed for WHH (in Figures 3.3 and 4.3) where females feature as the dominant worker, showing the greatest gender gap among the seven activity categories. As discussed in the previous section, the numbers of hours spent in WHH fluctuate greatly in site A, with such fluctuations existing equally for both males and females. In contrast, for site B, female WHH does not appear to be subject to seasonality, while male WHH is generally performed during the dry season.

Hours spent in WNR are limited on average compared with other activities (Figures 3.6 and 4.6), and are performed generally by women throughout the year because its objective is to obtain food items to supplement self-produced vegetables. However, in site A, males also engaged in this activity quite significantly during the 2007/08 dry season, but not in the 2008/09 dry season. This irregular performance of WNR by adult males is likely to be a response to the heavy rain shock.

Unlike other activities that indicate gender gaps, WSC is the only activity showing no gender difference with regard to hours spent, although time allocation for WSC fluctuated over the year (Figures 3.5 and 4.5).

WTL represents the sum of hours spent for all activities. Figures 3.8 and 4.8 show that in sites A and B male and female WTL hours moved in a similar pattern throughout the survey period and that females' working hours were always significantly longer than males. However, if we compare the two sites, the gender gap is larger for site B than in site A and co-movement is weaker in site B than in site A. As a result, the heavy rain increased working time for both males and females in site A, but affected only females in site B. Further investigation is still required regarding whether the different responses between the two sites are due to the differing impacts of heavy rain damage, income sources, custom or culture.

4.4. Adults and Children

Similar analyses were conducted to compare adults (19 year of age and above) and children (between 6 and 18 years of age). As shown in Figures 5.1 and 6.1, the hours children spent in WAG increased during the 2007/08 rainy season for both sites A and B, with a greater increase in site A than in site B. The results for WED (Figures 5.4 and 6.4) show that children's labor in WAG had little effect on WED as the heavy rain occurred during the holiday season. However, Figure 5.4 does show that WED at the beginning of the 2007/08 rainy season decreased to some extent. Thus, the heavy rain shock had a negative impact on the children's education via an increase in demand for household labor, but the impact was marginal. Since 2007/08, children's hours spent in WAG and WED exhibit normal seasonal movements.

Comparisons between sites A and B show that children in site A spent more hours engaged in WHH and WGR than those in site B (Figures 5.3, 6.3, 5.7, and 6.7). As a result, and as presented in Figures 5.8 and 6.8, WTL for children is also higher in site A than in site B, with children's working hours closer to site A adults than site B (i.e., the work time gap between adults and children is smaller in site A). Moreover, WTL hours for both adults and children move in a similar pattern in site A, with a weaker co-movement seen for site B.

Thus, the above analyses show us that children in site A are integrated to a greater extent in household economic activities and their working hours fluctuate in a pattern similar to adults. As a result, children in site A are required to spend more hours working in WAG, WHH, and WGR. These activities can affect their schooling but according to the time allocation data the impact on education is very small. This finding is consistent with the baseline survey results that the current enrollment rate in the study sites is relatively high and that there are no enrollment differences between the sites or gender.

5. Conclusion

We analyzed the impact of heavy rainfall on respondents' time use using weekly household survey data collected in rural Zambia. Our results showed that people, both adults and children, worked greater hours during the 2007/08 rainy season when a heavy rainfall occurred. Analyses were performed for male and female adults separately, to identify gender-differentiated impacts. A work response to the shock was confirmed for male and female adults in site A, and for females adult in site B. These results show that adult males in site B did not work longer hours (nor work less) in spite of the heavy rainfall shock. The difference may be attributed to the fact that crop damage from the heavy rainfall was less significant in site B, but the true reason is not yet known and needs to be studied in future research. Comparisons of time use between adults and children revealed that children in site A worked longer hours than those in site B. Because children worked more after the heavy rain, the shock may have affected the children's school attendance. In fact, children appear to have reduced schooling hours during the 2007/08 rainy season, but we believe this impact to be insignificant from the shape of the relevant graphs.

We used the same household data as Sakurai et al. (2011), who showed in their study that the heavy rain in December 2007 reduced food consumption per capita and the body weight of respondents significantly. The present paper contributes to the topic by identifying a further negative impact of the heavy rain, that is, longer working hours. Body weight loss may have been a result of not only reduced food intake but also due to a heavier workload. The welfare implications of fluctuations in work time and its determinants remain open to future study.

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Figure 1.1 Agriculture: Site A Full Sample

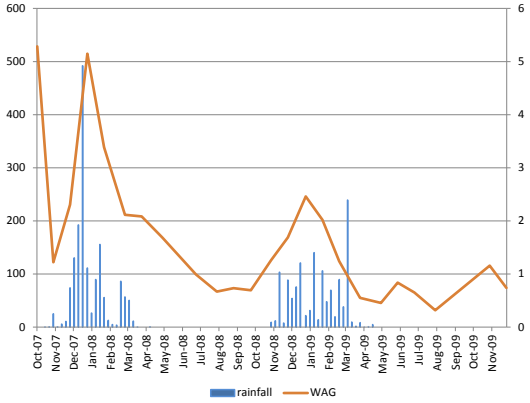


Figure 2.1 Agriculture: Site B Full Sample

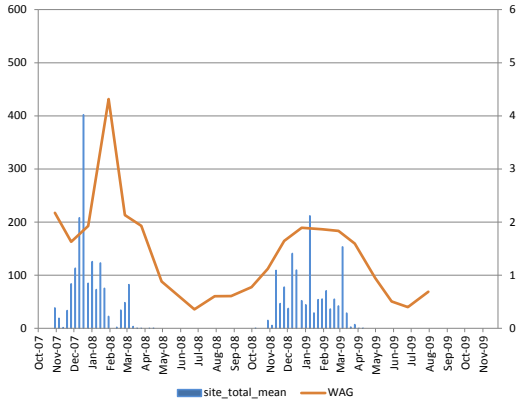


Figure 1.2 Non-Agriculture: Site A Full Sample

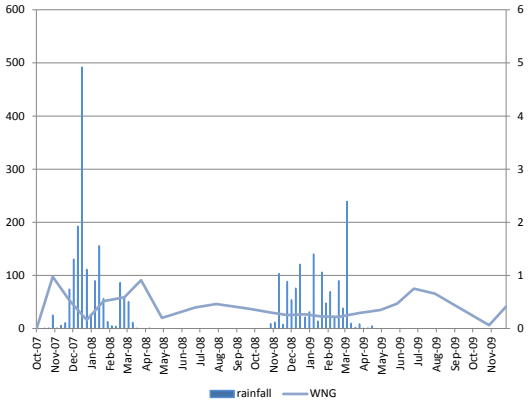


Figure 2.2 Non-Agriculture: Site B Full Sample

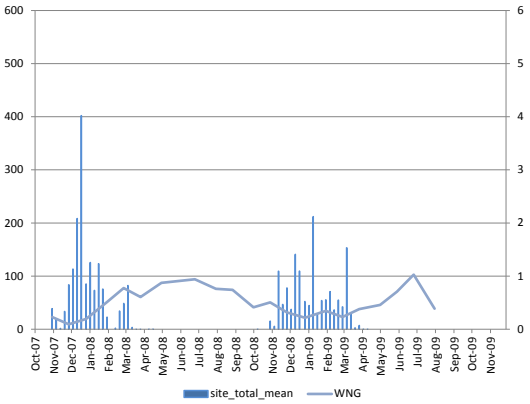
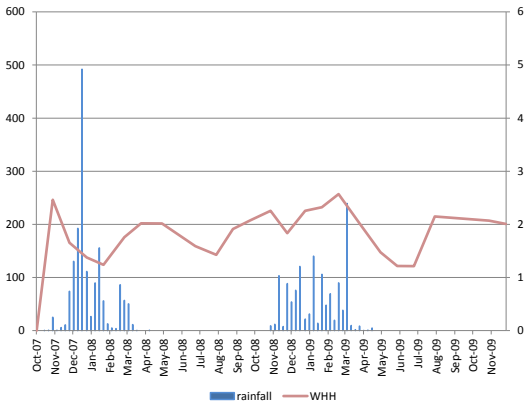


Figure 1.3 Domestic/help: Site A Full Sample



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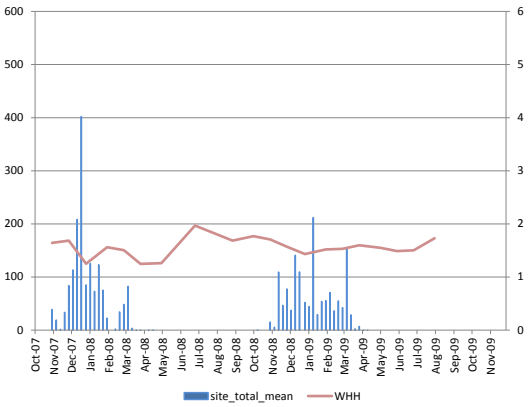

Figure 1.4 School: Site A Full Sample

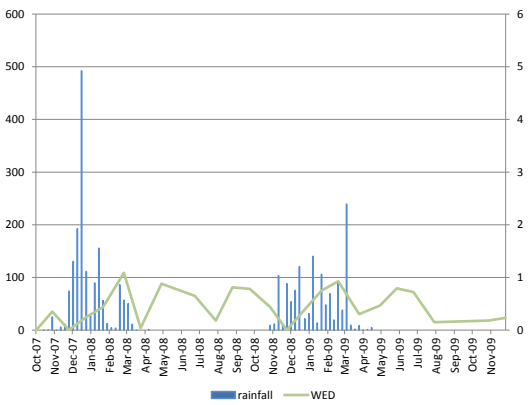

Figure 2.4 School: Site B Full Sample

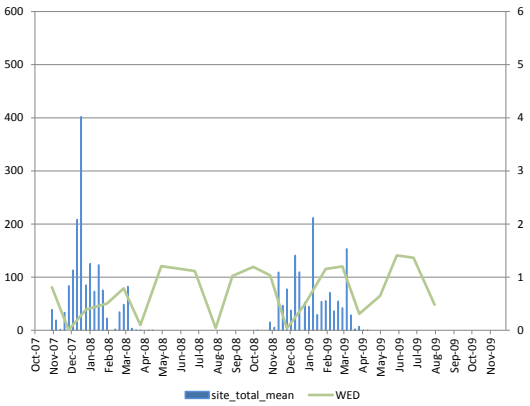

Figure 1.5 Social Activities: Site A Full Sample

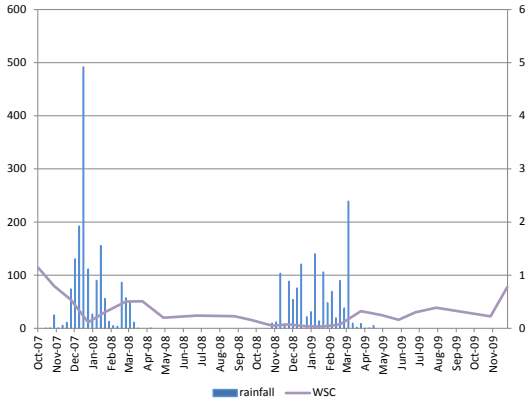

Figure 2.5 Social Activities: Site B Full Sample

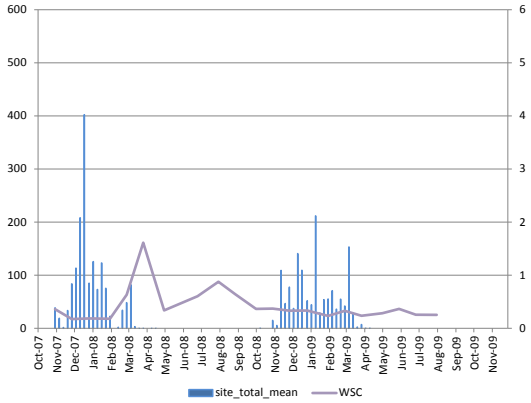

Figure 1.6 Natural Resource Collection: Site A Full Sample

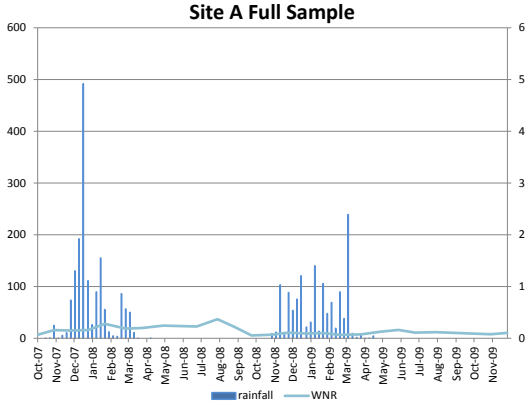

Figure 2.6 Natural Resource Collection: Site B Full Sample

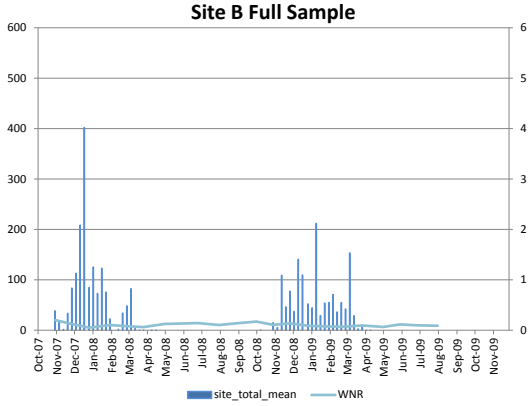

Figure 1.7 Grazing: Site A Full Sample

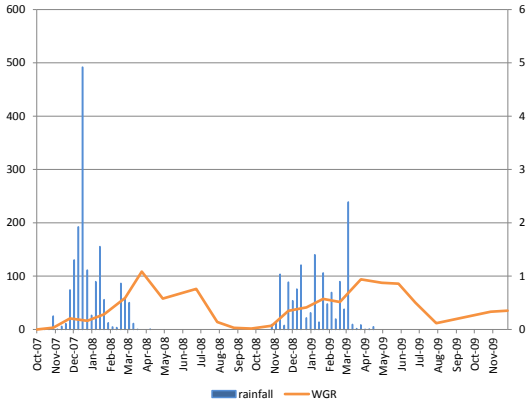

Figure 2.7 Grazing: Site B Full Sample

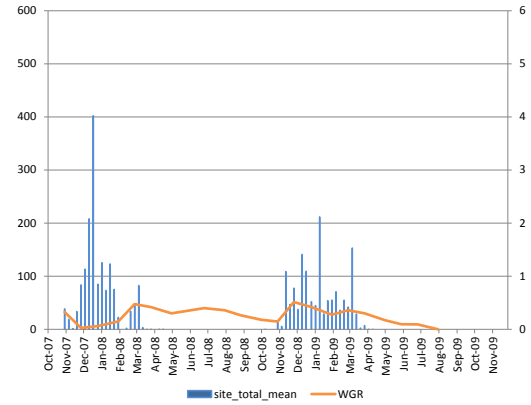

Figure 1.8 Total Work Time: Site A Full Sample

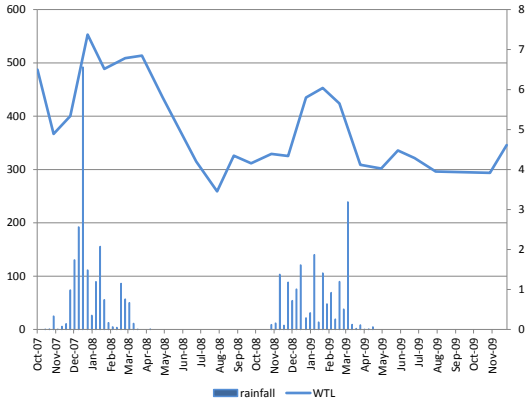

Figure 2.8 Total Work Time: Site B Full Sample

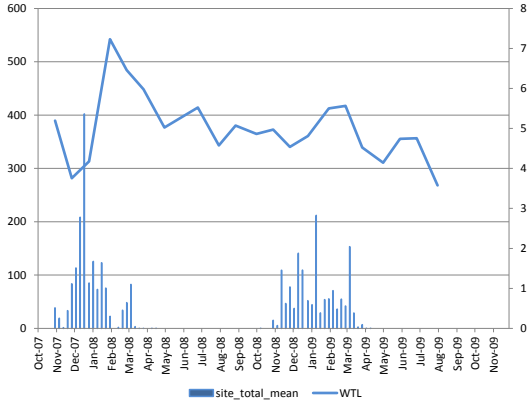

Figure 3.1 Agriculture: Site A Adult Sample

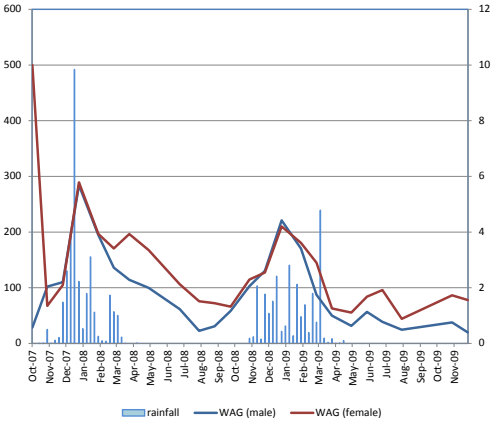

Figure 3.2 Non-Agriculture: Site A Adult Sample

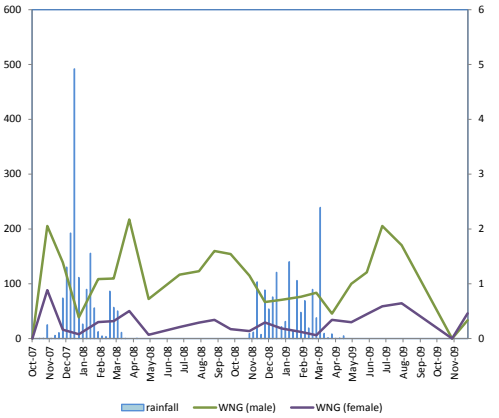

Figure 3.3 Domestic/help: Site A Adult Sample

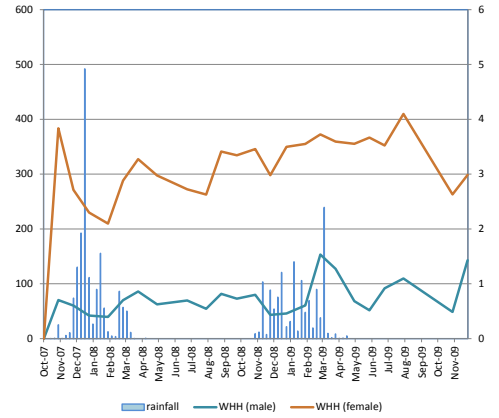

Figure 3.4 School: Site A Adult Sample

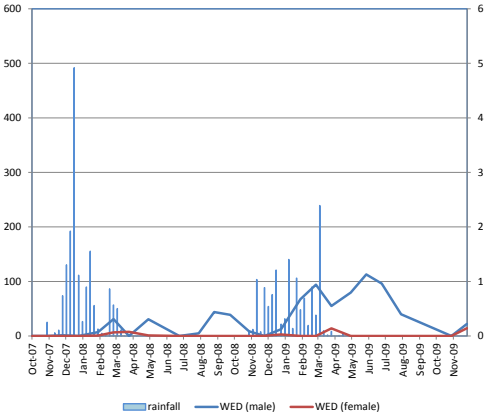

Figure 4.1 Agriculture: Site B Adult Sample

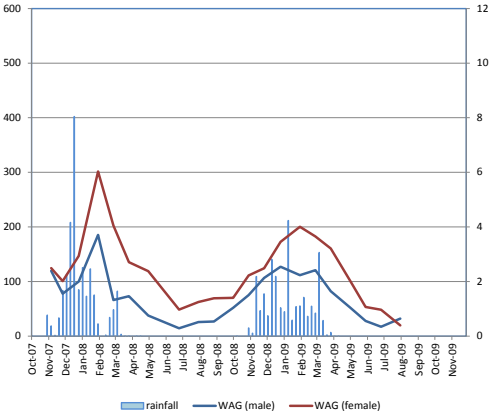

Figure 4.2 Non-Agriculture: Site B Adult Sample

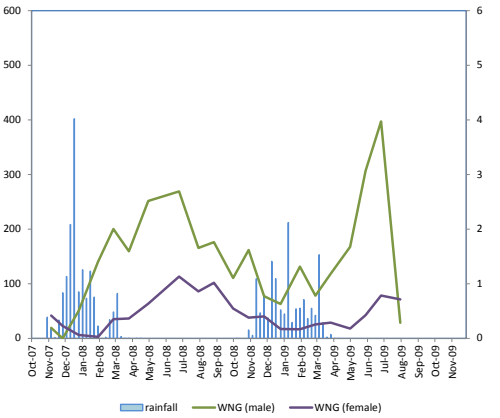

Figure 4.3 Domestic/help: Site B Adult Sample

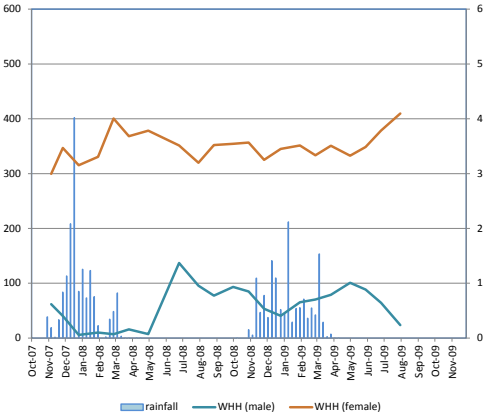

Figure 4.4 School: Site B Adult Sample

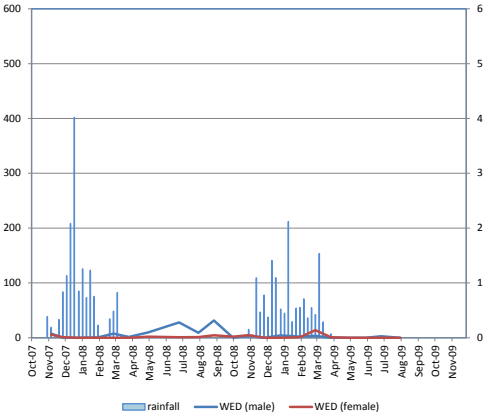

Figure 3.5 Social Activities: Site A Adult Sample

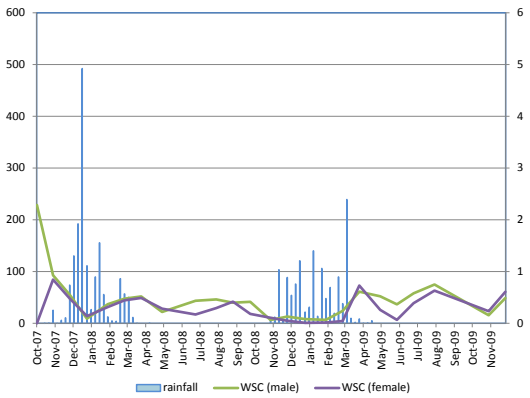

Figure 4.5 Social Activities: Site B Adult Sample

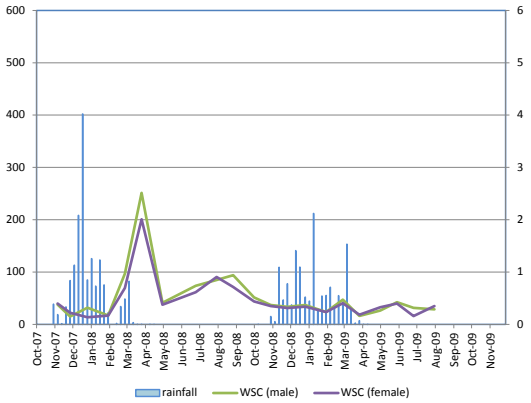

Figure 3.6 Natural Resource Collection: Site A Adult Sample

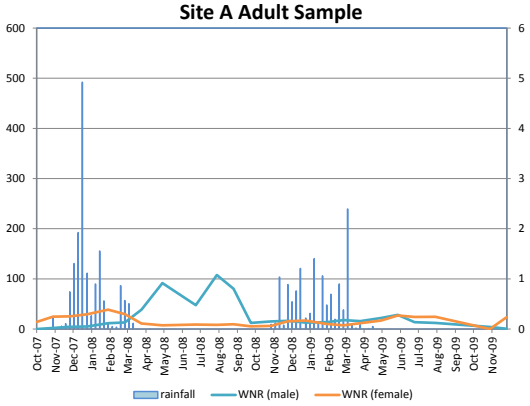

Figure 4.6 Natural Resource Collection: Site B Adult Sample

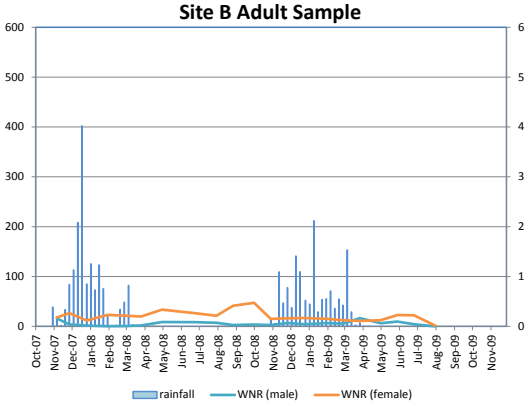

Figure 3.7 Grazing: Site A Adult Sample

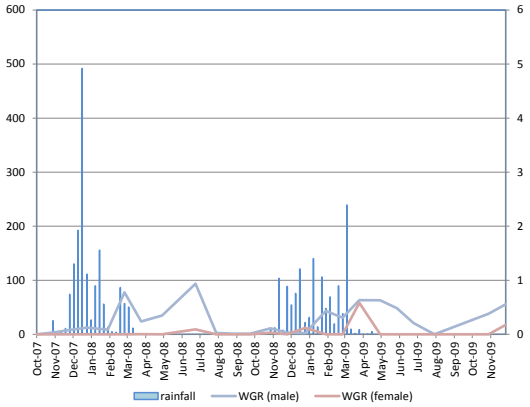

Figure 4.7 Grazing: Site B Adult Sample

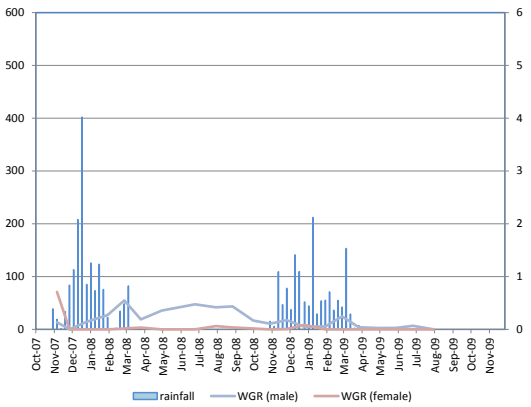

Figure 3.8 Total Work Time: Site A Adult Sample

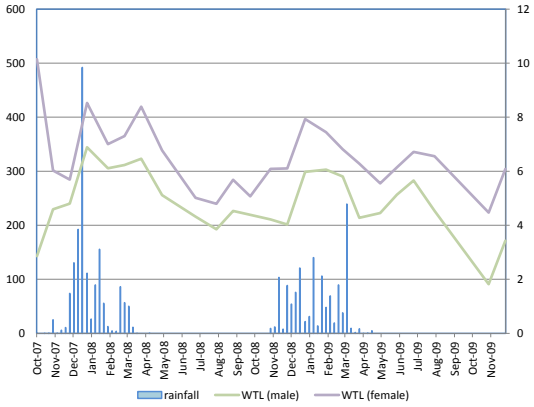

Figure 4.8 Total Work Time: Site B Adult Sample

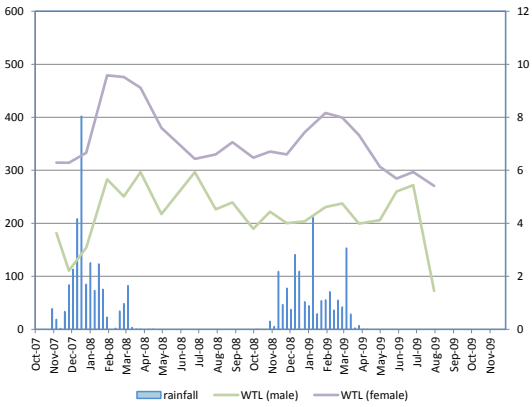

Figure 5.1 Agriculture: Site A Full Sample

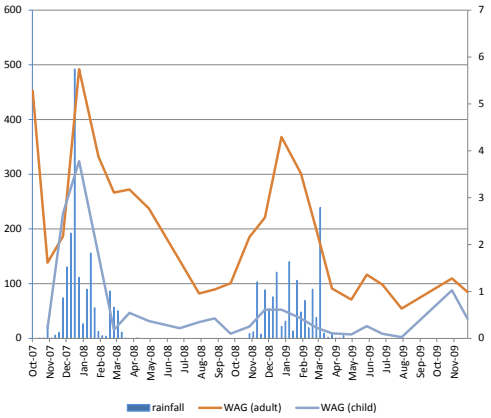

Figure 6.1 Agriculture: Site B Full Sample

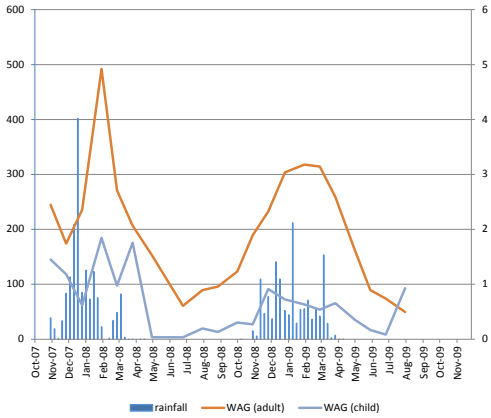

Figure 5.2 Non-Agriculture: Site A Full Sample

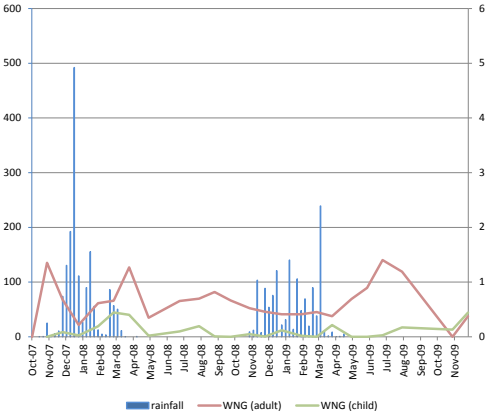

Figure 6.2 Non-Agriculture: Site B Full Sample

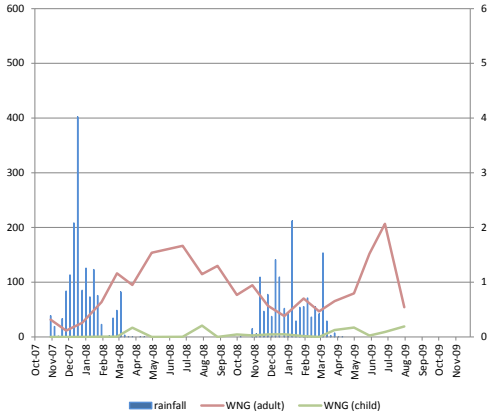

Figure 5.3 Domestic/help: Site A Full Sample

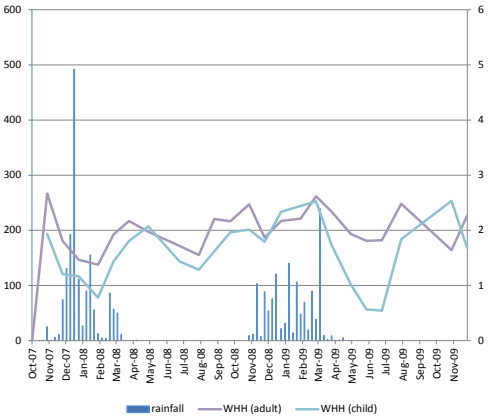

Figure 6.3 Domestic/help: Site B Full Sample

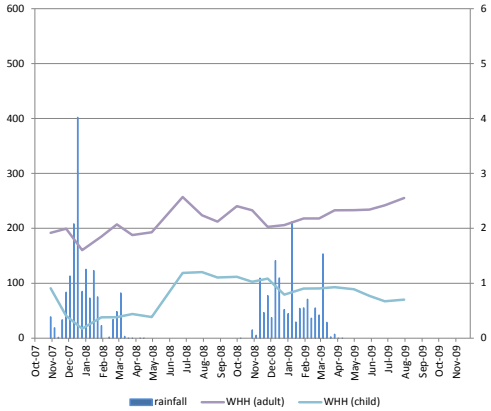

Figure 5.4 School: Site A Full Sample

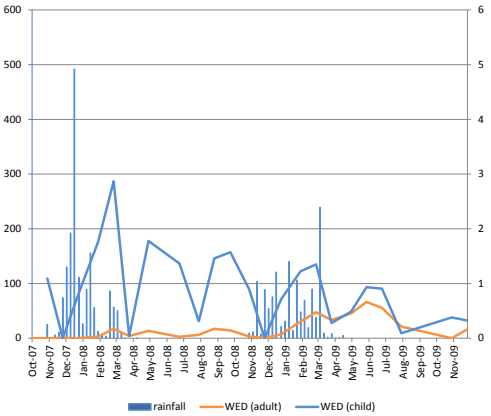

Figure 6.4 School: Site B Full Sample

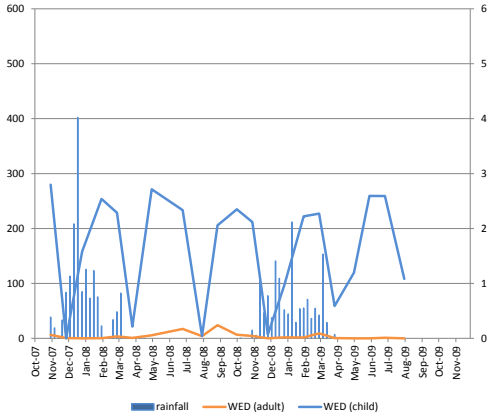

Figure 5.5 Social Activities: Site A Full Sample

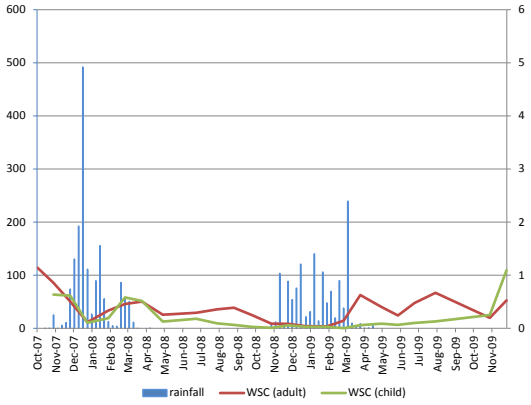

Figure 6.5 Social Activities: Site B Full Sample

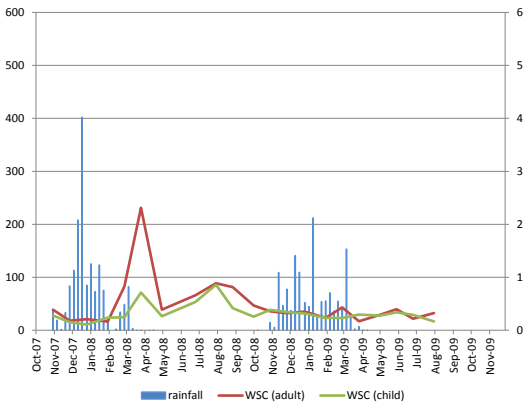

Figure 5.6 Natural Resource Collection: Site A Full Sample

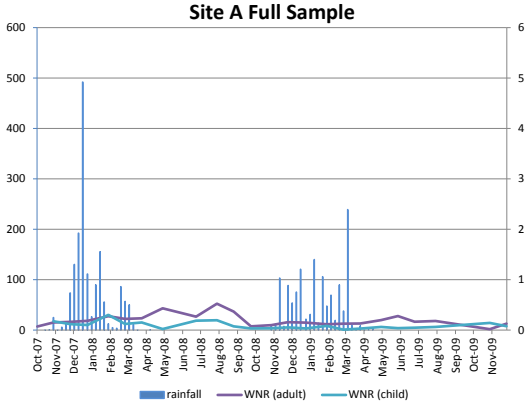

Figure 6.6 Natural Resource Collection: Site B Full Sample

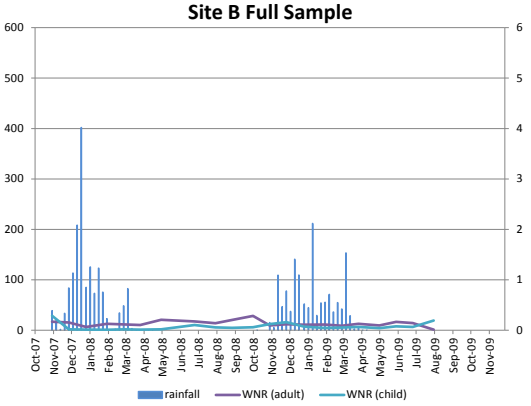

Figure 5.7 Grazing: Site A Full Sample

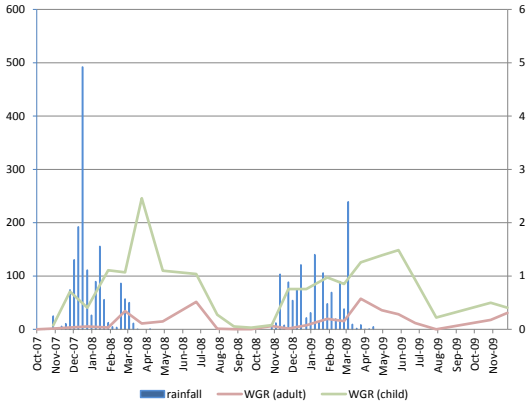

Figure 6.7 Grazing: Site B Full Sample

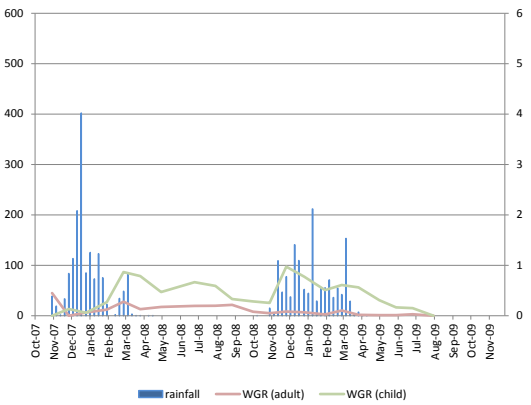

Figure 5.8 Total Work Time: Site A Full Sample

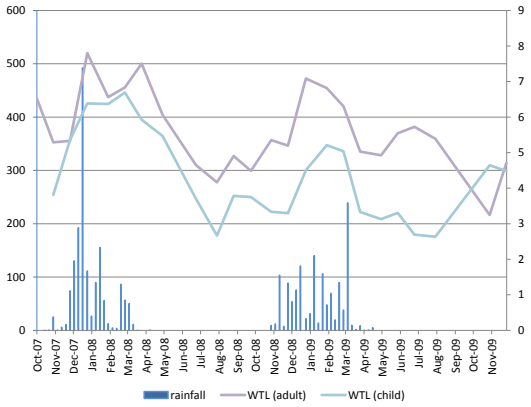

Figure 6.8 Total Work Time: Site B Full Sample