Impact of the 1997–1998 El Niño Rains on Farms in the Mount Kenya Region

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Impact of the 1997–1998 El Niño Rains on Farms in the Mount Kenya Region

The impacts of the 1997–1998 El Niño rains in the Mount Kenya region were heterogeneously distributed among agricultural villages in the area. The magnitude of these impacts on crop production depended on differences in the climatic and topographic conditions of the affected villages. Major food crops, especially beans and Irish potatoes, were ruined by the long-lasting rains in all villages, whereas banana and root crops, with the exception of Irish potatoes, received minimal damage. Because the less-susceptible crops were planted mainly in relatively humid villages on the upper slopes of the mountain, the differences in the impacts on the long-established upper and more recently settled lower villages became more apparent. Floods caused crop losses on the lower slopes but also deposited seeds of a useful tree species, resulting in a positive long-term impact of the El Niño rains. Farmers considered the El Niño rains to be much worse than a heavier rainfall event, the Mafuriko rains, experienced in 1961, suggesting that the magnitude of rainfall impact may not necessarily be determined by the amount of rainfall.

Keywords: *El Niño rains; flooding; farming; land use change; resettlement;* Cordia africana*; Kenya.*

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Introduction

The spatial pattern and magnitude of damage resulting from a disaster can be distributed heterogeneously across a region, particularly when the disaster is due to natural causes such as a drought, flood, landslide, or volcanic eruption (Sheets and Grayson 1979; Oya 2001). The consequences of a disaster and their severity are not always directly determined by the physical intensity of the disturbance. Rather, these consequences can be magnified or moderated by the topographic and climatic conditions of a disturbed site, as well as by social and cultural circumstances. For instance, the correlation between the magnitude and frequency of earthquakes within mountainous regions and the scale and incidence of accompanying disasters is very low (Hewitt 1997). Human activities that accompany land use changes and habitat abuse play a more direct role in earthquake vulnerability.

The 1997–1998 El Niño event was the strongest on record; it caused major climatic impacts on a global scale (McPhaden 1999). This event caused a wide variety of disasters, including drought in western and southern Africa and floods in East Africa that led to transportation disruptions and outbreaks of malaria, Rift Valley fever, and cholera (Kovats et al 1999; Karanja and Mutua 2000).

During this event, most parts of Kenya received 2 to 12 times the monthly long-term mean rainfall amount (Karanja and Mutua 2000). The heavy rainfall resulted in floods and landslides in various parts of the country (Ngecu and Mathu 1999), with consequent effects on water resources, agriculture, transport, health, and socioeconomic conditions. The estimated loss incurred by the agricultural sector alone reached USD 236 million (Karanja and Mutua 2000)—one-tenth of the gross domestic product.

The heavy damage suffered in rural areas of Kenya as a result of the 1997–1998 El Niño rains was distributed heterogeneously. For example, landslides did not occur everywhere but were triggered largely by human activities such as logging on slopes and vegetation degradation (Ngecu and Mathu 1999). Similar spatial variation in damage intensity occurred at a local level.

The impacts of natural disturbances can sometimes be positive rather than negative, and on occasion, the consequences can seem to be contradictory. For example, in the Semian Mountains of Ethiopia, excessive rain can harm crops in the highlands, but provide a source of irrigation for crops in the drier lowlands (Guinand 1999). The association of such ambivalent effects is common in areas prone to disturbances. In flood-prone areas, for example, the floods that inflict damage on some sectors of the population can also benefit fisheries and provide fertile soils (Okamoto 2002; Uchida and Ando 2003). Karanja and Mutua (2000) have suggested that the negative effects of the El Niño rains in Kenya may have been accompanied by positive effects, although neither excessive rain nor floods are common major hazards in this country.

The present study describes the spatial heterogeneity of the impacts arising from the El Niño rains in an area on the northeastern slopes of Mount Kenya, examines the causes of that heterogeneity, and ascertains any positive consequences of these rains in an area that is otherwise not prone to flooding.

Study area

Mount Kenya has long been inhabited by farmers, as the mountain provides both sufficient rainfall and fertile soils (Bernard 1972). Six villages were studied in the Buuri and Abothuguchi West divisions of the Meru Central district on the northeastern slopes of Mount

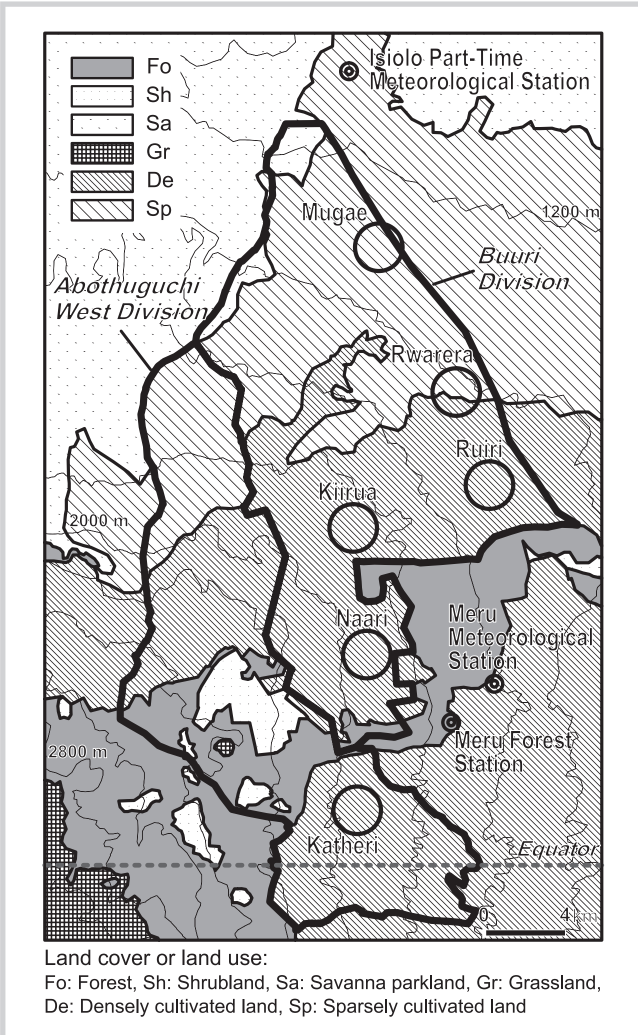

FIGURE 1 Location of villages and meteorological stations in the Buuri and Abothuguchi West divisions of the Meru Central district. Land use as of 2002 was mapped using Landsat TM imagery. The contour interval is 200 m. (Map by Sadao Takaoka)

Kenya: Katheri, Naari, Kiirua, Ruiri, Rwarera, and Mugae (Figure 1). These villages are inhabited by the Imenti, one of the ethnic groups of the Meru people. Rainfall decreases considerably with the decrease in altitude from Katheri to Mugae. The long-term mean rainfall values measured at the Meru Meteorological Station and the Isiolo Part-Time Meteorological Station are 1246 and 639 mm, respectively. Permanent streams run in valleys that deeply dissect the mountain slopes in the higher regions where Katheri and Naari are located, but only a few perennial streams exist in the small shallow valleys on the lower slopes.

Both upper villages, Katheri and Naari, receive adequate rainfall. Katheri was settled by the Imenti long before colonial times (Bernard 1972). A shortage of good farmland led some Imenti to migrate to the lower slopes, which receive less rainfall. These migrants established the new villages of Naari in 1937, Kiirua in 1955, Ruiri in 1957, Rwarera in 1967, and Mugae in 1980. Katheri and Naari are located in forested lands dominated by *Olea africana, Vitex keniensis*, *Croton macrostachyus*, *Ficus thonningi*, and *Podocarpus latifolius*, while Rwarera and Mugae are in wooded savanna populated by *Acacia xanthophloea*, *A. nilotica*, and *A. tortilis*.

This region experiences 2 rainy seasons, from late March to May and from mid-October to December (Figure 2). These rains make it possible to harvest major crops twice a year. The area around Mugae—the most recently settled village—is sparsely cultivated, and the area around Rwarera—the second-newest settlement—is in transition from sparsely to densely cultivated. The remaining villages are in densely cultivated areas (Figure 1). Maize (*Zea mays*), beans (*Phaseolus vulgaris*), and Irish potatoes (*Solanum tuberosum*) are major food crops in all villages. Tea (*Camellia sinensis*) and coffee (*Coffea arabica*) trees are grown mainly in Katheri and Naari, while sorghum (*Sorghum vulgare*) and millet (*Pennisetum typhoideum* and *Eleusine coracana*) have been planted in Rwarera and Mugae. Banana (*Musa* spp.) and root crops such as sweet potato (*Ipomoea batatas*), taro (*Colocasia antiquorum*), cassava (*Manihot utilissima*), and yam (*Dioscorea* spp.) are grown mainly on the upper slopes; these traditional crops were grown already before colonial times and used to provide famine relief in drought years (Bernard 1972).

Methodology

Farmers from 44 randomly selected farms in the 6 villages were interviewed in February 1999 to assess the effects of the 1997–1998 El Niño rains. Questions about the negative and positive impacts on crops and soils were asked in each interview. The farmers were also asked how long they had been living in the village, and whether they knew of other heavy rains than the 1997–1998 El Niño rains in the past. In three farms in Rwarera, invasion by some trees was observed. The diameter and height of these trees were measured on one farm in 1999. Re-measurement of the invading trees and additional interviews focusing on the trees were conducted in August 2000 and August 2004.

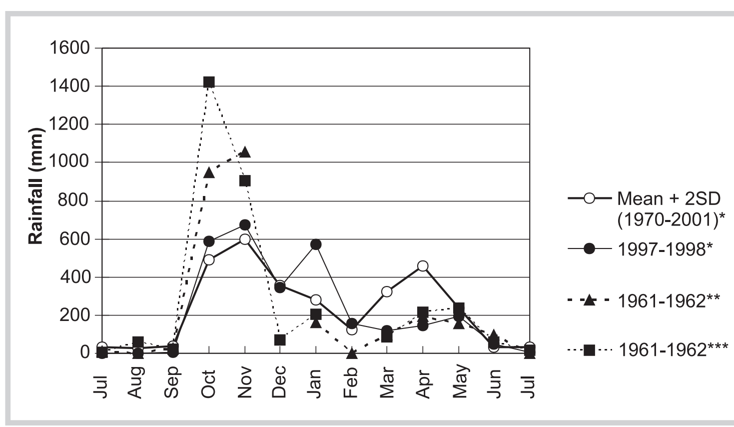

FIGURE 2 Observed rainfall for 1961–1962 and 1997–1998, recorded by the Meru Meteorological Station (*), Meru Forest Station (**), and Meru Agricultural Department (***). No data are available from the Meru Forest Station for December 1961, and from the Meru Agricultural Department for February 1962.

TABLE 1 Annual crop production in Buuri and Abothuguchi West divisions. The former Buuri division was subdivided into the present Buuri and Miligamieru West divisions in 1999. Data for Buuri shown in this table are from the present Buuri area. The yield for maize and beans in 1996 includes crops grown in October–December 1995 and harvested in 1996, as well as crops grown from March–May 1996 and harvested in 1996. Irish potatoes were mainly harvested in January–March. The last column shows the total rainfall from March to May in a given year and rainfall from October to December of the previous year recorded at the Meru Meteorological Station. The average total rainfall from March to May and from October to December between 1971 and 2001 was 1104.2 mm.

Crop	Maize (t)		Beans (t)		Irish potatoes (t)		Rainfall in rainy seasons (mm)
Year	Buuri	Abothuguchi West	Buuri	Abothuguchi West	Buuri	Abothuguchi West	
1996	—	8065	6158	5213	5220	63,634	1200.5
1997	138	8065	2156	6480	4884	63,695	1025.1
1998	486	18,873	900	6377	1458	59,220	2057.1
1999	131	2449	387	3567	9721	40,914	611.1

Rainfall data were obtained from the Kenya Meteorological Department, and crop production data were supplied by the Agricultural Department of the Meru Central district and agricultural offices in the Buuri and Abothuguchi West divisions.

Results

Heavy rains during the 1997–1998 El Niño event

Figure 2 illustrates long-term average rainfall, which shows a bimodal distribution corresponding to the 2 rainy seasons. Two heavy rainfall events occurred in 1961 and 1997–1998. In 1997, a rainfall amount 2.4 times higher than average occurred in the period from October to December, with 1602 mm of rain recorded in these 3 months at the Meru Meteorological Station. This amount is equivalent to the average annual rainfall at this station. The heavy rain continued until May 1998, causing an 8-month rainy season that included the 2 regular rainy seasons. The Imenti referred to this long rainy season as the El Niño rains. The heavy rainfall of 1961, the Mafuriko rains, was also remembered by locals (Figure 2). On this occasion, considerably more rain fell between October and December than in 1997. However, the Mafuriko rains were followed by a regular dry season in January–February, in contrast to the situation following the 1997–1998 El Niño rains.

Impacts on crop production

The major food crops, ie maize, beans, and Irish potatoes, were directly affected by the 1997–1998 El Niño rains, which spanned the 2 regular rainy seasons from late March to May and from mid-October to December (Table 1). In Table 1, the yield from the period of the El Niño rains is counted as of 1998 for the maize and beans that were grown in October to December 1997 and harvested in January–February 1998, as well as for Irish potatoes that were mainly harvested in January–March 1998.

Both the Buuri and Abothuguchi West divisions reported good harvests of maize in 1998. Beans and Irish potatoes failed in Buuri in 1998, but no such impact was found in the Abothuguchi West division. The yields did not recover in 1999, possibly as a result of the La Niña drought that followed the 1997–1998 El Niño event.

The impact on the crops according to the farmers interviewed is shown in Figure 3. The El Niño rains heavily damaged beans and Irish potatoes, but not maize, in all villages. Especially Mugae farmers experienced a better maize harvest than usual. Banana and root crops such as sweet potato, taro, cassava, and yam were minimally damaged on most farms. Observations of crops on all farms, including those on which farmers were not interviewed, indicated that these particular crops were planted mainly in the less dry villages: taro and yam were planted on most farms in Katheri and Naari, and occasionally in Kiirua and Ruiri; banana and cassava were planted in Katheri, Naari, Kiirua, and Ruiri, but rarely in Rwarera, and never in Mugae; and sweet potatoes were planted in all villages except Mugae.

The impact of the El Niño rains varied among the 6 villages. Farmers reported that crop failure occurred in part from a shortage of sunlight, fungal diseases, rot, waterlogging, and uprooting by floods. Floods devastated farms only on the lower slopes, ie in Kiirua, Ruiri, Rwarera, and Mugae (Figures 3 and 4). Soils were severely eroded by rainwater, particularly in areas of black cotton soil (Hackman et al 1989), a dark-gray clay soil that formed on even surfaces within the lower slope areas. On the upper slopes, only slight erosion occurred, which was limited to the steeper slopes along valleys. The El Niño rains were viewed favorably by farmers in Mugae, who credited the rains with enhancing their harvest of maize, sorghum, and millet.

These subjective harvest returns agree with those reported in documents of the Agricultural Department of the Meru Central district and the agricultural offices of the Buuri and Abothuguchi West divisions. These documents record heavy losses of beans and Irish potatoes following the El Niño rains, but indicate that with the exception of Irish potatoes, the production of other root crops was fair or quite good. A Buuri division agricultural officer reported that a good maize yield had been harvested on the drier, lower slopes, including Mugae.

Farmers from 29 farms remembered the Mafuriko rains of 1961, but only 5 of them indicated that the Mafuriko rains caused more severe damage than the El

Village	Farm #	Flooded	Sorghum	Millet	Maize	Beans	Irish potato	Sweet potato	Banana	Cassava	Taro	Yam
Katheri	1				P	N	N				A	
	2				A	N	N	A	A	A		P
	3				P				A			
	4				A							
	5				N							
	6				A		N		A	A		A
	7				P	N	A					
Naari	1				A	N	N	A	A		A	
	2				A	P	P	A				
	3				A	N	N	A				
	4				A	N	N					
	5				A				A			
	6				P	N	N	A	A	A		A
	7				P	N	P	A	A			
	8				N	N						
Kiirua	1				P	N						
	2				P	N	N					
	3				N	N	N	A				
	4				P		N	A				
	5				N			P				
	6				P	N	N	A	A	A		
	7				P	N	N	A				
	8	●									A	
	9				A	N	N	A				
Ruiri	1				P	N	N					
	2				P	N	N	A	A			
	3				N			A	A	A		
	4				P	N	N	A	A			
	5	●										
	6				A	N	N	A	A			
	7	●						N				
	8	●						N				
	9				N	N		A	A	A		
Rwarera	1				N			N				
	2				N	N	N	P		P		
	3				A	N						
	4				P	N		A				
	5				P	N	N	A	A	A		
	6	●	N		P	N	P	A				
	7	●			P	N		A				
Mugae	1		A	A	A	N	N					
	2		A	A	A	N	A					
	3		A		A	N						
	4	●			N							

Legend:
A Average or above-average harvest
P Poor harvest
N No harvest

FIGURE 3 Impacts of the 1997–1998 El Niño rains on food crops in 44 farms in 6 villages, as assessed by the farmers. "Flooded" indicates farms inundated by floods in 1997–1998.

Niño event. Six farmers indicated that the Mafuriko rains were quite favorable for cropping. However, many of the farmers interviewed had migrated from their original villages to newer villages between 1961 and 1997. Only 10 farmers still lived in the same villages as in 1961. Of these 10, 6 regarded the El Niño rains as having had a greater impact than the Mafuriko rains.

Useful trees brought by the El Niño floods

The El Niño rains negatively affected most of the interviewed farmers, but 3 farms in Rwarera reported a positive result from the floods despite crop losses. *Muringa* (*Cordia africana*) saplings appeared on these farms following the floods (Figure 5). *Muringa* is a broad-leaved deciduous tree that grows in high-rainfall areas of Kenya. This tree has many uses in the core agricultural zone on the humid, upper slopes of Mount Kenya, and has also proven useful to farmers who migrated to the new villages on the relatively dry, lower slopes (Takaoka 2002). Farmers from the 3 farms reported that *muringa* seeds deposited by floods germinated on their farms in the new soils and subsequently became established. At least 31 *muringa* saplings taller than 1 m were present on one farm of about 1 ha in February 1999, 1 year

FIGURE 4 A house in Ruiri. Note the lower half of the whitewash, which peeled off the wall following the January 1998 floods. (Photo by Sadao Takaoka, February 1999)

FIGURE 5 A *Cordia africana* sapling invading a farm in Rwarera. The banana tree in the background was transported from the upper slope area by a flood. (Photo by Sadao Takaoka, February 1999)

after the inundation; most were 1.0–1.5 m in height. Some were subsequently thinned out; 18 saplings remained by August 2000 and 14 were still there in August 2004. By then the highest was 7.0 m in height, 17 cm in diameter at breast height, and 27 cm in diameter at ground level.

Discussion

Differences in impact among villages

The magnitude of the damage caused by the 1997–1998 El Niño rains in terms of crop production in the study area varied with the climatic and topographic conditions prevailing in the different villages. Climatic conditions, especially the amount of rainfall in normal years, were related to whether the El Niño rains affected each village positively or negatively. The rains were most favorable for the Mugae farmers, who experience the lowest rainfall amount of the 6 villages in normal years. These farmers obtained a better maize harvest than usual. The increased maize yield for the Buuri and Abothuguchi West divisions (Table 1) resulted from improved production in villages (such as Mugae) that are normally dry. Topographic conditions controlled the places where floods occurred. Rainwater flowed along the deep valleys that dissect the upper slopes, but in lower areas, floodwater inundated farms when the shallow valleys overflowed. Soil erosion was also spatially heterogeneous; severely eroded sites were observed usually in black cotton soil areas on the lower slopes.

The differences experienced in crop damage among the 6 villages in part reflect differences in the susceptibility of each crop type to the El Niño rains (Table 1 and Figure 3). Major food crops, especially beans and Irish potatoes, suffered in all villages, while bananas and root crops, with the exception of Irish potatoes, were minimally affected. These less-susceptible crops are primarily planted in relatively humid villages in upper-slope areas. This implies that the drier, lower slopes have agricultural disadvantages, not only because of unreliable rainfall (Bernard 1972), but also because of their greater susceptibility to abnormal weather conditions and their smaller variety of famine reserve crops.

Positive impact of the El Niño rains

Overall, the short-term effects of the El Niño rains on villages were negative. The long-lasting rains ruined crops, and floods disrupted the farms. However, from a long-term perspective, the rains also had a positive impact, by providing farmers in Rwarera with *muringa* trees that produce green manure, fodder, shade for crops, fuelwood, timber, and string (Nzioka 1991; ICRAF 1992). Prior to the floods, these farmers had had little success in establishing *muringa* in Rwarera, as this species tends to be intolerant of less humid soils.

The diameter of *muringa* fruits is ≥10 mm. Numerous dried fruits commonly litter the ground beneath *muringa* trees, and such seed fruits can be carried by sheet runoff from the upper slopes—where *muringa* are abundant—to the lower farms without the aid of wind or animals. The more humid conditions prevailing during the El Niño rains may have facilitated germination of the seeds and establishment of seedlings in the otherwise semi-arid environment of Rwarera.

Differences in impact between the El Niño and Mafuriko rains

The magnitude of rainfall's impact may not depend strictly on the amount of rainfall. Farmers considered the impacts of the 1997–1998 El Niño rains to be more extensive than those of the 1961 Mafuriko rains, although rainfall between October and December in 1961 was greater than that in 1997 (Figure 2). A possible reason is the concentration of the Mafuriko rains in the regular rainy season of October to December, with the rains then stopping before January 1962. In the 1997–1998 El Niño event, rainfall continued throughout the normal harvest season in January 1998, which led to the extensive rotting and uprooting of unharvested crops.

A second reason relates to differences in crop variety in 1961 as compared to that of 1997–1998. In 1961, farmers grew fewer food cash crops such as maize, beans, and Irish potatoes and fewer non-food cash crops such as coffee and tea. Food cash crops proved highly susceptible during the El Niño rains (Figure 3). Arabica coffee was introduced in 1935 and developed extensively in the 1950s, when it displaced yams and bananas (Bernard 1972). The continued change in crop variety in the last 40 years may have narrowed the tolerance of agriculture to climate fluctuations (de Vries 1985).

Differences in response to the El Niño and Mafuriko rains also probably resulted from migration from upper to lower slopes after the Mafuriko rains. Gentle slopes, some of which are almost flat, dominate the lower areas where the new villages have been established. Flooding occurred under these topographic conditions. People who had resettled to these new villages had probably never experienced inundation while they inhabited the upper slopes.

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