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Using an ecological economics approach to support the restoration of collapsing gullies in southern China

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ABSTRACT

Land degradation and poverty are problems that must be tackled together for environmental conservation to succeed. However, it is rarely possible to move a population from degraded land to another area where the people can be more easily sustained. To find a new strategy that achieves both conservation and economic gains without the need to relocate a population, we examined/investigated a sustainable combination of ecological and economic development suitable for the restoration of areas of China with collapsing gullies, where the frequent steep slopes make restoration difficult. The results showed that the degraded land may contain significant benefits that were previously unappreciated, thereby transforming a problem into an opportunity. Our results suggest that the new approach can both improve the livelihoods of local citizens and promote environmental conservation, leading to successful ecological restoration.

Introduction

In areas that receive more precipitation than the soil can absorb, erosion caused by the resulting runoff can create gullies with steep slopes that are formed by a combination of intense runoff and gravity (Avni, 2005; Zhang, 2010). Where there is insufficient vegetation to prevent the runoff from creating gulley erosion, steep slopes develop and subsequently collapse under the influence of gravity (Fig. 1, top). This phenomenon is common where the slopes are steeper than 75°; in the red clay soils region of southern China, the annual erosion in these areas averages 50 kt km^{-2}, which is more than 50 times the erosion on gentler slopes or on slopes with a high vegetation cover (Zhang, 2010). There are hundreds of such degraded ecosystems in China's Loess Plateau (Chen and Cai, 2006) and in the granitic red clay soils area of southern China (Zhang, 2010), which stretches from 21°01′N to 32°05′N and from 106°49′E to 120°27′E.

The flooding, debris flows, and other disasters that result from this form of erosion jeopardize sustainable development in regions of China that have steep slopes and degraded land combined with low vegetation cover (Chen and Cai, 2006; Zhang, 2010). From 1950 to 2005, erosion and gulley collapse affected 1220 km^2 in the granitic red clay soils region, leading to the loss of more than 60 Mt of soil; this, in turn, caused the loss of 380,000 ha of farmland, 554,000 houses, 37,000 km of road, 11,000 bridges, 9000 reservoirs, and 73,000 ponds, as well as 0.38 billion RMB in economic losses that affected 11.62 million residents (Zhang, 2010). Unfortunately, there is currently no effective approach to prevent such disasters, and tens of millions of Chinese citizens live in areas vulnerable to this kind of erosion (Cao et al., 2010).

Monitoring data reveals that collapsing gullies are widespread in China's granitic red clay soils area, which includes Hubei, Hunan, Jiangxi, Anhui, Fujian, Guangdong, and Guangxi provinces. Since 2000, the Monitoring Center of Soil and Water Conservation of China (Zhang, 2010) has reported more than 239,000 collapsing gullies, affecting an area of 122,000 ha (Table 1). It is clearly essential to find an approach capable of restoring this degraded land that can also improve the livelihoods of the local population to avoid the need for relocation or emigration of these people. To accomplish this, a new strategy named "An Ecological Economics Approach for the Restoration of Collapsing Gullies" was tested in Changting County, in Fujian Province of southern China.

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Fig. 1. Photographs of part of the study area near Shiwa Village, Sanzhou Town, Changting County: (Top) Collapse of a steep slope as a result of erosion when vegetation cover was insufficient to reduce runoff and protect the soil. (Middle) Restoration work in its early stages, showing development of the terraces. (Bottom) Successful stabilization of the slope 9 years after revegetation of the terraces.

Photo credit: Yanmin Xie obtained the pictures in May 2001 (top), October 2001 (middle), and May 2009 (bottom).

Changting County established one of the earliest soil and water conservation monitoring stations in China, in 1940 (Yang et al., 2005). However, a half-century of unsustainable cutting of forests, combined with a rainy climate and mountainous topography, have led to active development of a system of collapsing gullies, leading to severe land degradation. These conditions have contributed to the inability of the degraded sites to recover naturally (Gao et al., 2011). The combination of degraded land, a lack of vegetation cover, and high inputs of rain have increased the frequency and scale of water erosion of the soil and the severity of flooding, leading to further degradation of the county's forests and landscape. In 2005, monitoring revealed 3585 collapsing gullies in the county, covering 6304 ha (Zhang, 2010). The flooding, debris flows, and other disasters caused by the collapse of these gullies due to erosion have seriously jeopardized sustainable development in the county (Yang et al., 2005). For example, flooding on 8 August 1996 caused the loss of an astounding 93,367 ha of farmland, as well as 1.2 billion RMB in economic losses that affected 296,000 residents, with 398 residents hurt and 96 residents killed (Yang et al., 2005). The severity of this damage led to the launch of an aggressive erosion-control program in the county. Since 1996, the conventional method of erosion control has involved the installation of diversion channels that direct runoff away from steep slopes, and this approach has been widely used since 1996 (Yang et al., 2005).

Table 1
Numbers and areas of collapsing gullies in parts of China where gully collapse is a serious problem.

Province	Collapsing gullies		Planned conservation of vulnerable areas (ha)
	Number	Area (ha)	
Hubei	2363	538	1705
Hunan	25,838	3739	21,674
Jiangxi	48,058	20,675	42,001
Anhui	1135	356	2008
Fujian	26,023	7339	50,210
Guangdong	107,941	82,760	111,846
Guangxi	27,767	6598	14,192
Total	239,125	122,005	243,636

Data are from 2005 (Zhang, 2010).

Note: The area of planned conservation includes vulnerable areas around collapsing gullies where runoff is entering the gully. Therefore, the values in this column are larger than the areas in the previous column.

However, although the conventional approach can mitigate the problem, it has not eliminated the problem and it provides no economic benefits to local residents. To alleviate the damage caused by the land degradation that leads to this erosion and to improve the livelihoods of local residents, an old Chinese strategy has been reinvented: terrace engineering (Fig. 1, middle), followed by revegetation with trees and crops (Fig. 1, bottom). This approach, which combines environmental engineering with economic development, has been tested in Changting County since 2001. The strategy is designed to collect precipitation in the terraced farmland, retaining water so that the water cannot form the large quantities of surface runoff that would create erosion. As a result, the terraces retain both the soil and its nutrients, and protect the farmland's soil properties (Cao et al., 2007). In accordance with the principle of working with rather than against nature, appropriate vegetation is planted in the terraced land to retain the soils. This represents an improvement over the conventional method because it provides socioeconomic benefits and improves the livelihoods of local residents. To accomplish this, crops are planted in the terraces nearest to residential areas, fruit trees are planted 1 km or more from the residential areas, and timber trees are planted 2 km and farther from these areas.

To understand the benefits of this new approach based on ecological economics, we undertook a monitoring study to explore the potential for revegetation of steep slopes by planting appropriate vegetation. We compared the new methods with the existing (conventional) method on steep slopes with the goals of sustaining the functional characteristics of the landscape, protecting the slopes, and improving the visual and other characteristics of the study area, while also increasing the income of local residents. Our results showed that the new techniques can improve the protection of ecosystems in steep terrain while dramatically improving vegetation restoration, soil conservation, and sustainable socioeconomic