

Orchards on Eroded Uplands of Southeast China: Sustainability or Abandonment?

Sady na zerodowanych wyżynach pół.-wsch. Chin: zrównoważoność czy problem?

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Abstract

Orchard development on eroded uplands is considered as a successful method in integrating soil erosion treatment with economic development in many developing countries. However, much attention focused on its present achievements without thinking over the economic viability over long plantation duration. Orchards that have not been intensified seem to be threatened by complete abandonment. To illustrate the economic viability and sustainability of orchard management, we have deliberately focused on a case study in Southeast China. The results of economic viability based on a cost-benefit analysis showed that orchard management was barely economically sustainable. Their viability is assured if reduced labor costs and increased fruit price are accepted. Based on these results, recommendations are made to prevent the abandonment of orchards on degraded uplands and to preserve its environmental benefits.

Key words: soil erosion, rural livelihoods, sustainability, cost-benefit analysis, China

Streszczenie

Tworzenie sadów na zerodowanych wyżynach w wielu krajach rozwijających się jest traktowane jako metoda udanie łączącą zintegrowane przeciwdziałanie erozji gleb z rozwojem ekonomicznym. Niestety, zbyt mocno podkreśla się znacznie szybkich osiągnięć, bez rozważania kontekstu wieloletniej opłacalności takich działań. Sady, których nie poddano modyfikacjom, opuszczono. By zilustrować ekonomiczną sensowność i zrównoważoność zarządzania sadami, wybrano jako case study obszar pół.-wsch. Chin. Rezultaty oceny opartej na analizie kosztów i korzyści wykazały, że zarządzanie sadami okazuje się być słabo ekonomicznie zrównoważone. Opłacalność pozostała zapewniona w przypadku obniżenia kosztów pracy i podniesienia cen owoców. Na podstawie przeprowadzonych badań przedstawiono rekommendacje, których uwzględnienie umożliwiłoby zaprzestanie procederu rezygnacji z prowadzenia sadów na terenach zdegradowanych wyżyn i utrzymanie korzyści środowiskowych.

Slowa kluczowe: erozja gleb, poziom życia rolników, zrównoważoność, analiza kosztów i korzyści, Chiny

1. Introduction

Soil erosion is one of serious threats to rural sustainability in many tropical developing countries (Das and Bauer, 2012). The fragile hilly ecosystems in these areas provide many important ecosystem ser-

vices and sustain the livelihoods of poor rural households (Persha et al., 2011). It is widely accepted that environmental degradation and poverty are closely linked and both should be tackled together in poor mountainous regions (Cao et al., 2009; Cao et al., 2010). In other words, conservation projects must

properly deal with the trade-offs between human livelihoods and conservation (Sunderland et al., 2008; Sandker et al., 2009; Bielinska et al., 2015). Selection of practical methods linking conservation with development is a premise for conservation projects.

There are many ways to link conservation with livelihoods. Among these ways, the promotion of alternative livelihood strategies (such as orchard development, tourism), which would divert local populations away from their (ostensibly) harmful traditional practices towards new forms of employment, is a prevalent method (Brown, 1998). By virtue of better spatial suitability, orchard development on degraded uplands as one of typical alternative income generating activities is widely used in developing countries. The method of orchard development was considered successful in reconciling sustainable livelihoods and ecological conservation (Wang et al., 2011; Wang et al., 2012; Soltani et al., 2012). In detail, orchard development could provide many jobs and produce revenues. Moreover, the maintenance of orchards on degraded uplands is benign for the environment, as these systems show low rates of soil erosion and high levels of biodiversity (Loumou and Giourga, 2003).

However, orchard development was not the panacea for conservation. The economic viability and sustainability of orchard management would directly decide the long-term effect of conservation projects (Khakbazan and Hamilton, 2012). Practically, two main factors threaten traditional orchard cultivation on degraded uplands, favoring its abandonment: competition from intensive orchards in flat and fertile land, and higher natural threats and risks deriving from poor site conditions. Moreover, increasing rural labor costs deriving from urbanization and industrialization is also another disadvantage. These disadvantages worsened the economic viability of orchard management on degraded uplands.

Like many other parts of the world, orchard development in partial sites with better natural endowments and socio-economic conditions is one of the important alternative livelihoods to link conservation with development in China (Wang et al., 2015a). A lot of literatures highly evaluated the achievements of orchard management in ecological and socioeconomic aspects based on current surveys (Cao et al., 2009; Wang et al., 2011; Li et al., 2011). However, orchard development and management has a long duration (e.g. 30 years). Economic evaluation based on one complete rotation of orchard management would be rational. Excessive optimism and over-evaluating on orchard management based on survey data of full bearing age fruit trees may conceal the economic risk, challenge, and unsustainability emerging in the near future. Thus, economic viability and sustainability analysis based on scientific methods – (esp. the whole duration of orchard man-

agement) is vital for conservation effectiveness assessment.

Based on above analysis, economic feasibility and sustainability is pivotal for sustainable orchard conservation. If a lot of orchards were abandoned due to poor economic profit, the results would not only bring about negative livelihood impacts, but also lead to new soil erosion (Wang et al., 2015b). Both failures in conservation and development would induce other socio-economic problems. To avoid the dilemma, the governments should adopt a series of measures to ensure the sustainability of the orchard management. The assessment of economic viability and sustainability would be a prior step for governmental policy-making.

In this article, a study case that achieved preliminary success in conservation through orchard development was selected. Our major goals were to examine the economic viability and sustainability of orchard management from a long-term perspective. Several economic analysis methods including Net Present Value (NPV), Internal Rate of Return (IRR), and sensitivity analysis were used for assessment. And we also put forward some advice to promote the sustainable orchard management.

2. Methods

2.1. Study area

Changting County is located in western Fujian Province of Southeast China ($25^{\circ}18'40''N$ to $26^{\circ}02'05''N$, $116^{\circ}00'45''E$ to $116^{\circ}39'20''E$), and situated on the southern part of WuYi Mountain (Figure 1). It is characterized by a humid, subtropical monsoon climate with high mean precipitation ($1730.4 \text{ mm yr}^{-1}$) and warm annual temperatures (a mean of 18.3°C and a minimum temperature of 7.9°C), and it is primarily covered by loose granite red soils (Wang et al., 2015a). Historically, it was covered by luxuriant vegetation with light soil erosion. However, a half-century period of human destruction worsened soil erosion, leading to extreme decreases in biodiversity and soil fertility (Wang et al., 2011).

To mitigate ecological degradation, the county government has made great efforts in conservation since 1950s. Some limited and phased ecological restoration had been achieved. However, the impoverished rural households returned to the predatory deforestation driven by higher livelihood pressure (Wang et al., 2011; Wang et al., 2012). Fortunately, the recent conservation project started from 2000 has achieved integrated success in conservation and livelihoods (Cao et al., 2009; Wang et al., 2011; Wang et al., 2012). Different from foregone conservation projects, the kernel of new conservation policy was to combine the conservation and development through alternative livelihood strategies. The degraded ecosystem treatment transferred from solely governmental activity to governmental protection and soci-

ety-oriented (mainly farmer-oriented) pattern under the guide of local government. Besides the large-scale government-oriented ecological treatment (such as closing hillsides to facilitate afforestation, tree planting and afforestation, collapse mound treatment), developing economic forests (mainly orchards including tea gardens) on open forest land or barren hills with convenient transportation and relatively light soil erosion by the rural households was one of important measures (Wang et al., 2011). To promote the activity, the government encouraged the planting of fruit trees by providing compensation of \$ 237.72ha⁻¹ (1 U.S. \$=6.31 RMB in 2012, the same below). And to encourage rural households to use organic fertilizers to improve plant growth, the local government offered subsidy of \$ 16.10 for each additional pig (Cao et al. 2009). As a result, according to the statistical data of Changting Bureau of Water and Soil Conservation, the newly planted fruit trees (such as red bayberry, ginkgo, Chinese chestnut, peach, tea) amounted to 2623.03 hectares sponsored by the governments from 2000 to 2009, accounting for 3.19% of the total treatment area. In addition, to encourage individual participation and reduce the cost of management, the government propelled the transfer of land ownership to residents who were willing to plant trees (Wang et al., 2011).

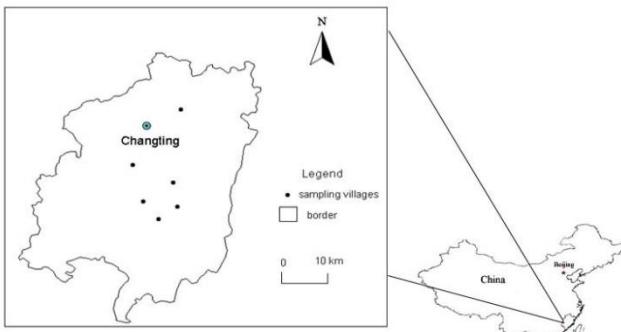


Figure 1. The location of the study area

2.2. Data Collection

To specially research the economic feasibility and sustainability of orchard management for participants who contracted and planted large-scale economic fruit trees. We adopted typical sampling survey to avoid omission by random sampling. According to in-depth interviews of Changting County's Bureau of Agriculture, Bureau of Forestry, Bureau of Water and Soil Conservation, we conducted 30 face-to-face interviews with typical rural households (with more than 6.67 ha orchards) based on an inventory of households during August 15 to August 31 in 2012. Then we accomplished 30 valid questionnaires (Including 10 red bayberry growers, 10 chestnut growers, and 10 other fruit growers). As a result, we gained 30 effective and accurate questionnaires about farmers with large-scale orchards.

Moreover, we designed a cash flow table of past orchard management to gain input-output conditions. The economic analysis needs a lot of precise cost and benefit data with a long duration. Owing to poor economic profit, many orchards (such as chestnut, peach, pear orchards) were abandoned or extensively managed in Changting County. Only profitable orchards with a better market demands could be intensively managed during a long period (Figure 2).



Figure 2. Photographs of abandoned red bayberry orchards(Top) and intensive managed red bayberry orchards(Bottom) in Sanzhou Town, Changting County.

Given data availability, we choose the most profitable orchard management – red bayberry management – to show the overall economic benefits of orchard investment in Changting County. The intensive orchard management would need extremely more input than extensive management. To gain comparability and scientific results, we solely selected red bayberry orchards which were developed in 2001 and intensively managed since 2001 for survey. The interviewed householders recalled the input and output of their orchards during the past management by memory or account books. After detailed face-to-face interviews, we obtained the ultimate cash flow data of red bayberry management in Changting County. The specific survey data could be seen in subsequent parts. To promote the comparability of data in different years, all prices were converted to comparable prices of 2012 to remove the effect of inflation.

2.3. Calculation of NPV and IRR

Orchard management is a kind of private investment. A rational economic benefit is the most important precondition. Based on previous literature, Net Present Value (NPV) and Internal Rate of Return (IRR) are two vital assessment criteria for investment decision-making. If orchard management is a wise investment, the NPV should be positive and the IRR should be higher than the guiding rate of interest. The related calculation formula is shown as follows:

$$NPV = PV(\text{benefits}) - PV(\text{costs}) = \sum_{t=0}^n \frac{B_t}{(1+r)^t} - \sum_{t=0}^n \frac{C_t}{(1+r)^t} \quad (1)$$

Where NPV is net present value of the project, B_t is the economic benefits in year t , and C_t is the corresponding costs. In addition, r is discount rate, expressed the annual rate of interest or inflation rate, and n is the duration of the project in years.

The Internal Rate of Return is the interest rate that satisfies the equation:

$$\sum_{t=0}^n \frac{B_t - C_t}{(1+R)^t} = 0 \quad (2)$$

Where R is the internal rate of return of the project, the other indicators are the same as above.

2.4. Sensitive analysis

The cost-benefit analysis is based on limited information about past and current costs and benefits, the results would only clarify the past economic viability. However, past experience cannot represent future economic sustainability because of great changes in input and output prices. Sensitivity analysis is used to test the assumptions and to specify the uncertainty of economic benefit. It is a method for examining the quantitative effect of a certain change on each parameter to output values, and it improves understanding of the critical elements on which the outcome of an intervention depends (Shigematsu et al., 2013). The variables we focused on were wages, inputs, market prices, and final transferring prices of orchards.

In the sensitivity analysis, we used the limits of the analysis based on the historical price trends in research site. In order to generate rational scenarios of element and commodity price changes, we collected a great deal of credible history data to determine limits of change. As far as the material input price is concerned, great changes have taken place since 2001. According to the statistical data of National Bureau of Statistics of China, during 2001-2012, the average retail price of granular urea made in China, ammonium bicarbonate, DAP, and NPK(15-15-15) increased by 45.14%, 39.36%, 41.52%, and 38.90% respectively. Their mean increment is 41.23%. Thus, we set two cases to quantify the response to different material input prices: increasing by 20% (half increase extent of chemical fertilizer during 2001-2012) and 40% (total increase extent of chemical fertilizer during 2001-2012).

As for the increase of labor costs, the rural labor costs in Changting County increased more rapidly in 21st century. According to our survey, the wages of one unskilled and middle-aged woman for doing some relatively easy farm work (such as weeding, pruning bushes, picking fruits) increased from 22 RMB in 2001 to 60 RMB in 2012, increased by 172.73%. Referring to historical growth, we examined two cases to show the influence of increasing wages on NPV and IRR of orchard management: increasing by 50% and 100% respectively.

As far as the price of fruits is concerned, the average price of fruits remained relatively steady in recent years. In detail, the average wholesale price of red bayberry increased from 9.70 RMB kg⁻¹ in 2007 to 13 RMB kg⁻¹ in 2012, increased by 33.97% during 5years. We set two cases to quantify the impact of changing fruit price on NPV and IRR: increasing by 20% and 40%. In addition, the final transferring price of orchards could influence the outcome of cost-benefit analysis. The value to a large extent depends on future expectations of orchard management. Owing to great panic derived from a contagious disease in red bayberry trees, many orchard managers have forced to sell their orchards at low prices since 2012. We set the transferring price at 2000 RMB mu⁻¹, 4000 RMB mu⁻¹, and 5000 RMB mu⁻¹ to quantify the impact of orchard selling price on the profitability of red bayberry plantations.

3. Results

3.1. Economic benefits of orchard management

Before proceeding to economic analysis, the specific rotation of orchard management and the discount rate should be defined. Owing to the sampling orchards being developed in 2001, we could not gain the whole rotation data. However, the transferring price of 12-year-old red bayberry orchards per acreage and past cash flow data could also be used to calculate the economic feasibility. The time horizon in the cost-benefit analysis was set at 12 years to correspond to the cash flow data during 2001-2012. Moreover, the discount rate should be determined to consider the time value of money. According to the official data of China, during the period of 2001-2012, the mean annual rate of interest of commercial bank loan for 5-year term was 6.23%. And the mean annual rate of interest of private lending was about 10%.

Most rural households with no formal mortgage had to turn to private lending. Thus, 8% was selected as the discount rate to calculate the present value of orchard management.

After calculation, we got the precise cash flow of red bayberry management and NPV and IRR. As shown in Table 1, the total net cash inflow of red bayberry management per mu amounted to 4929 RMB (Including orchard transferring value). The NPV of red

Table 1. Red bayberry cash flow in Changting County, Unit: RMB, our field survey in 2012

Item	Total	Year												
		1	2	3	4	5	6	7	8	9	10	11	12	13
Cash inflow														
(1) Fruit Yield (kg)	1900							120	250	300	400	480	350	
(2) Cash inflow	20670							960	2000	3000	4400	5760	4550	
Subtotal	20670							960	2000	3000	4400	5760	4550	
Cash outflow														
(1) Land rent	84	84												
(2) Soil preparation	1500	1500												
(3) Seedling	167	167												
(4) Patch planting	20		20											
(5) Fertilization	4630	360	350	360	350	360	360	380	380	400	430	450	450	
(6) Weeding	1650	200	150	150	100	100	100	120	130	140	140	160	160	
(7) Pesticide	1770	20	50	50	120	150	150	170	180	200	220	230	230	
(8) Tree pruning	2520			50	100	200	200	220	250	250	250	500	500	
(9) Fruit picking	3150							150	250	500	700	700	850	
(10) Tool	1250	150		150			150		200	100	250		250	
(11) Soil and water conservation facility	800		500									300		
(12) Others	1200	50	50	50	50	50	50	100	100	150	150	200	200	
Subtotal	18741	2531	1120	810	720	860	1010	1140	1490	1740	2440	2240	2640	
Net Cash inflow	4929	-2531	-1120	-810	-720	-860	-1010	-180	510	1260	1960	3520	1910	3000
NPV	-618													
IRR	6.54%													

Notes: (1) The cash flow calculation is based on 1/15 ha; (2) All the prices is constant at 2012 (1 USD=6.31 RMB in 2012); (3)The fruit yield fluctuates due to climate and life cycles.

Table 2. NPV and IRR of red bayberry orchard management under different material input price and wage change

Indicators	Base case	Input price +20%	Input price +40%	wage+50%	wage +100%
NPV (RMB)	-618	-1675	-2882	-3525	-6432
IRR (%)	6.5	4.1	1.45	-0.11	-6.85

Note: the area unit is mu, 1mu=1/15 hectare, the same below.

Table 3. NPV and IRR of red bayberry orchard management under different output price and orchard transferring price change

Indicators	Base case	Fruit price +20%	Fruit price +40%	OP-1000	OP+1000	OP+2000
NPV (RMB)	-618	1274	3165	-986	-250	118
IRR (%)	6.54	10.70	14.11	5.55	7.44	8.25

Note: OP=orchard transferring price; OP-1000, OP+1000, OP+2000 means that the final orchard transferring price is 2000RMB, 4000RMB, 5000RMB respectively.

bayberry management was -618 RMB per mu. The negative value showed that orchard investment was uneconomic during 2001 to 2012. And the IRR was 6.54%, which was also lower than the discount rate. Through above economic analysis, it could be concluded that the investment in red bayberry management was not feasible in research site.

3.2. Sensitive analysis of orchard management

To evaluate the effects of future changes in input/output price on profitability of orchard management, a sensitivity analysis was carried out. As previously mentioned, the change scope of the input price was generally set at 50% and 100% change during 2001-2012. Results showed that orchard management was sensitive to increase of input costs.

The reduction of NPV and IRR was 171.04% and 36.54% with 20% increase in material input price. And the reduction of NPV and IRR was 366.34% and 65.66% for the 40% material input price increase (Table 2). The change extent in NPV and IRR were all higher than related change in material input price. As for the response of wage increase, results showed that the reduction of NPV and IRR was 470.39% and 101.68% for the 50% wage increase. The reduction of NPV and IRR was 940.78% and 103.06% with 100% wage increase (Table 2).

Results showed that orchard management was more sensitive to increase of fruit price (Table 3). The NPV became positive with the increasing fruit price. The increase of IRR was 63.61% and 115.75% with 20% and 40% increase of fruit price respectively,

which was greater than material input price with the same change. Moreover, orchard management became profitable when fruit price increased 20%. The final orchard management also affected the outcomes of the cost-benefit analysis. The NPV was -986 RMB mu^{-1} , -250 RMB mu^{-1} , and 118 RMB mu^{-1} , when the orchard transferring price was 2000 RMB mu^{-1} , 4000 RMB mu^{-1} , and 5000 RMB mu^{-1} – respectively.

4. Discussion and Conclusions

Our results demonstrated that orchard management in Changting was not as profitable as previously discussed (Cao et al. 2009). The NPV of red bayberry management was -618 RMB per mu, and the IRR was 6.54%, which was also lower than the discount rate. The negative value of NPV and smaller IRR all proved that orchard investment was uneconomic during 2001 to 2012. Many factors determined the economic viability of orchard management, such as poor natural endowment (esp. severe soil erosion, poor soil fertility), a great deal of investment in water and soil conservation, delayed fruit bearing period, and future expectations.

Among these factors, future expectations to a large extent decided the final transferring price of orchards. However, a strange contagious disease with the symptoms of rotting roots and death occurred and spread in 2012. Most orchards were affected by the disease. So far, no agricultural professionals could provide effective countermeasures. As a result, the relatively poor profit in 2012 could be partly attributed to the contingency. The disease not only affected the orchard output, but also induced great panic and pessimistic expectations of future orchard management. If right prescription could be proposed, the transferring price of orchards would increase greatly. The outcomes of the cost-benefit analysis would be remarkably different.

Results of sensitivity analysis indicated that the profitability of the orchards was most sensitive to wages. The variation of economic benefit was the highest for wages if all the costs and price had the same variation scope as the past 12 years. With increasing industrialization, urbanization, and agricultural labor productivity in China, wages of rural labors have increased remarkably during the past decade. Being a more labor-intensive system, orchard management showed a significant economic loss resulting from increasing wages. Higher labor costs could promote the advance of agricultural technology and labor-saving activities. But the technology lag and labor-intensive characteristic of orchard management would aggravate current difficulties. As a result, rapidly increasing rural wages became the crucial threats for sustainability of orchard management. In addition, fruit price is another relatively sensitive factor to the profitability of orchards.

Orchard abandonment is usually related to a variety of socio-economic and environmental consequences. As far as the socio-economic consequences are concerned, orchard abandonment could not only result in waste of land resources, but also produce negative effects in employment and rural livelihoods. As previously discussed, orchards had ever been a significant socio-economic role, as it provided an important source of income and employment for some rural households. Moreover, orchard abandonment would also have negative environmental consequences (Duarte et al., 2008). The primary environmental impacts included increased soil erosion, homogenous landscape, increased risks of wildfires, changes in future land use, and decrease in biodiversity (Viana, 2003). Among these aspects, the most important negative impact in research area was increasing soil erosion, which may have wide on-site and off-site adverse effects.

Thus any policy intervention towards improving market promotion, enhancing transportation infrastructure, integrating leisure tourism with fruit picking, scientific and normative orchard management in the hilly region that reduces the costs of labors and increases the fruit price would increase profitability to the farmers' investment over orchards.

First, market promotion and better traffic accessibility could expand market size and induce rising price of production.

Second, integrating leisure tourism with fruit picking is a popular sales method, which could save a lot of labor costs.

Third, scientific and normative management is the most important basis for sustainability of orchard management.

According to our survey, the contagious disease of fruit trees may well be derived from extensive management, because orchards with intensive management were less affected by the disease. In addition, normative management could reduce pesticide residue of fruits in order to form positive market image and geographical brand.

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