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Analysis

Spatial patterns and economic contributions of mining and tourism in biodiversity hotspots: A case study in China

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ABSTRACT

Mining activities and tourism are both growing fast in biodiversity intense areas globally. However, the dynamic and interactions between mining and tourism when they both occur in biodiversity hotspots, and how they together may impact the economy and environment in these biodiversity rich areas, remain unclear. This paper examined how the two industries interact in terms of their economic contributions and spatial patterns in a biodiversity hotspot, Yunnan, China. We used correlation analyses to measure the relationships between mining activities, tourism visits and local gross domestic productions. We also employed a distance-based technique to investigate the nature of any dependency between mining and tourism sites. Results showed that mining activities tend to be in relatively fluent areas while tourism tends to occur in less developed areas. Our results showed that the location of tourism and mining sites are likely to be close to one another but the two industries usually perform better economically when they are apart from each other. These findings can provide insights on how mining and tourism together may impact the economy and environment in biodiversity rich areas, and provide important information for managers and planners on balancing mining and tourism development in these areas.

1. Introduction

Biodiversity hotspots, mining and tourism have been studied extensively as separated subjects (e.g. Malcolm et al., 2006; Arabsheibani and Labarthe, 2002; Shen and Gunson, 2006). However, the dynamic and interactions between mining and tourism when they both occur in biodiversity hotspots remain unclear. This article aims to bring some insights in this aspect through a case study at a biodiversity hotspot in China. In the following subsections, we will first briefly introduce the history and relevant studies of biodiversity hotspots. To illustrate the importance and potential applications of this study, we will then present the great geographic overlaps among biodiversity hotspots, mining sites and tourism development. Finally, we will present a review of studies regarding mining and tourism's impacts on economy and environment of the hosting communities.

1.1. Biodiversity Hotspots and its Geographic Overlap with Mining and Tourism

Biodiversity hotspots were developed by Myers et al. (2000) as a strategy to prioritize conservation efforts. In their paper, Myers et al. provided a ranking for areas of biodiversity in order to assist planner in the face of insufficient funding. Twenty-five biodiversity hotspots were defined. The authors estimated that it may be possible to protect 44% of all vascular plant species and 35% of 4 major vertebrate groups by focusing conservation efforts on these biodiversity hotspots, which only takes 1.4% of the earth's surface (Myers et al., 2000). The list was expanded to 34 hotspots later, which became the major focus of Conservation International (CI). Several socioeconomic dimensions of biodiversity hotspots have been examined, such as population densities and growth rates (Cincotta et al., 2000), and governance corruption (Smith et al., 2003). In particular, Fisher and Christopher (2007) indicated there are great overlaps between severe poverty and biodiversity hotspots.

In the recent twenty years, mining and tourism industries have been found active in these areas of poverty and biodiversity hotspots. Studies showed nearly one third of active mines and exploration sites are within areas of intact ecosystems or high conservation value (e.g. Miranda et al., 2003). According to Bridge (2004), a growing proportion of mineral exploration and investment expenditures targeted areas of high conservation value including the tropical Andes, the Guiana Shield, Indonesia, Papua New Guinea, the Philippines and tropical West Africa. In the meanwhile, tourism grew much faster in the areas of poverty and biodiversity. Of the poorest 100 countries, over half have a tourism industry that is growing and/or significant (Deloitte and Touche, 1999). Research showed biodiversity intense areas have a great overlap with

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countries of an average annual tourism growth over 100% since 1990 (Christ et al., 2003). This great overlap was presented visually by overlying together the maps for poverty and biodiversity hotspots (Fisher and Christopher, 2007), major mining activities (Miranda et al., 2003), and tourism growth (Christ et al., 2003) (Fig. 1).

1.2. Mining and Tourism's Impacts on Economy and Environment

The social, economic and environmental impacts of mining or tourism industries have been examined by numerous studies. Positive and negative impacts were found for both industries. The negative impacts associated with mining include land degradation, ecosystem disruption, and negative impacts on the local community (i.e. sexually-transmitted diseases) (The World Bank, 2004). In many studies, mining has been found to impede the overall economic performance (Power, 1996; Davis, 1998; Auth, 1993; 1991, 1998; Gelb, 1988; Kremers, 1986) because of the exhaustible characteristic of mineral resource and the sole reliance of mining industry to support a country's economy. However, other studies show mining could bring positive impacts on incomes and jobs when it is positioned as an important supplement instead of a principal support of the local economy (e.g. Shen and Gunson, 2006).

The negative impacts of tourism include land degradation, water pollution, waste and noise brought by tourists, and overwhelming pristine cultures by the modern lifestyle (Butter, 1980). On the positive side, tourism generates income and job opportunities. Furthermore, tourism, especially ecotourism or nature-based tourism, is promoted by environmental organizations (such as CI, World Wild Foundation, and The Nature Conservancy) to increase environment awareness among visitors and finance conservation work (WTTC and IHRA, 1999; Brandon, 1996; Christ et al., 2003).

Both mining and tourism have been recognized for their positive roles in alleviating poverty by providing jobs and income to local communities. Such economic contributions are essential to biodiversity hotspots considering the great geographic overlaps of mining, tourism, poverty and biodiversity hotspots (Fig. 1) and complex relationship between alleviating poverty and conserving biodiversity (Sachs et al., 2009). However, when mining and tourism coexist in a relatively small area (i.e. a biodiversity hotspot), choices of locations for specific sites and the economic outcome from each mining or tourism site might be different from when they exist alone due to limited resources (such as land) and the impacts from each other (such as policy restraint on mining around tourism attractions, or negative pollution impacts on tourism from mining sites). Coexistence of mining and tourism and their competition for land use have been recognized and studied in Africa, northern Canada, and South America (e.g. Weigend, 1985; Temu and Due, 2000; Ironside, 2000). Some studies compared mining and tourism as different income sources and favored tourism over mining for less environmental impacts (e.g. Weigend, 1985; Temu and Due, 2000; Ironside, 2000). Other studies recognized conflicts in land use, management and development policy between mining and tourism (Sinclair Knight Merz, 2000).

While socioeconomic and environmental impacts of mining and tourism and the land use conflicts between them have been studied, few studies have examined the relationship and the spatial interaction between the two industries, especially in the areas of biodiversity hotspots. The research presented here aims to fill this gap in a biodiversity hotspot in Yunnan, China. We ask two questions specifically. First, do mining and tourism industries reinforce or impede each other in terms of their economic contributions? Second, what is the spatial pattern of the locations of mining and tourism sites? Do they tend to cluster or avoid each other? Answers to these questions will provide important insights on how mining and tourism together may impact the economy and environment in biodiversity hotspots.

With development of both tourism and mining, some mining sites became tourism attractions where visitors learn about the history and how technology evolved of mining. Such attractions are referred as “mining heritage tourism”. While in many cases, mining and tourism remain as two separate activities. This study focuses on the latter scenario to explore their spatial relationship and interactions.

2. Study Site: Yunnan, China

To address our two questions, we focus on one of the 34 global biodiversity hotspots — Yunnan, China (Fig. 2). Yunnan province is located in the southwest China. It encompasses 393,898 km^2, and has

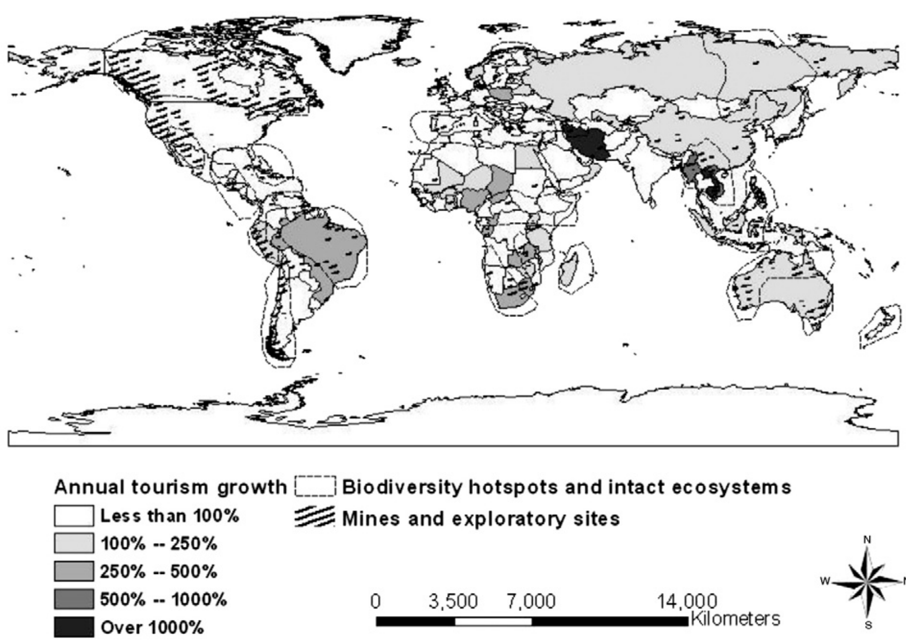

Fig. 1. Overlaps among major mining sites, area with great tourism expansions and ecological hotspots. (Sources: Christ et al., 2003; Fisher and Christopher, 2007; Miranda et al., 2003).

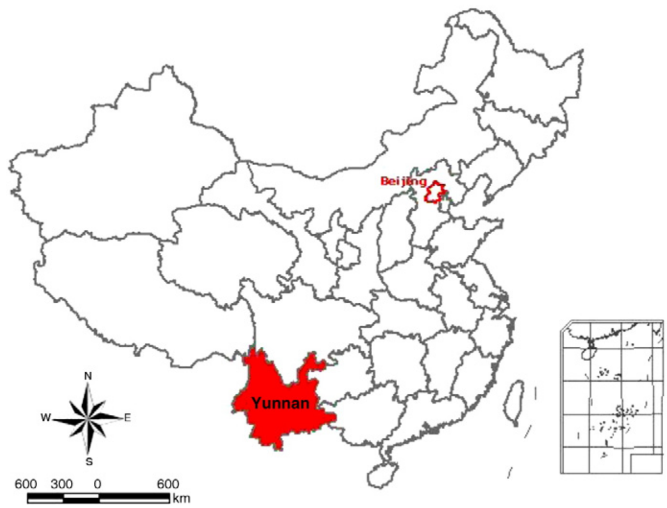

Fig. 2. Yunnan, China.

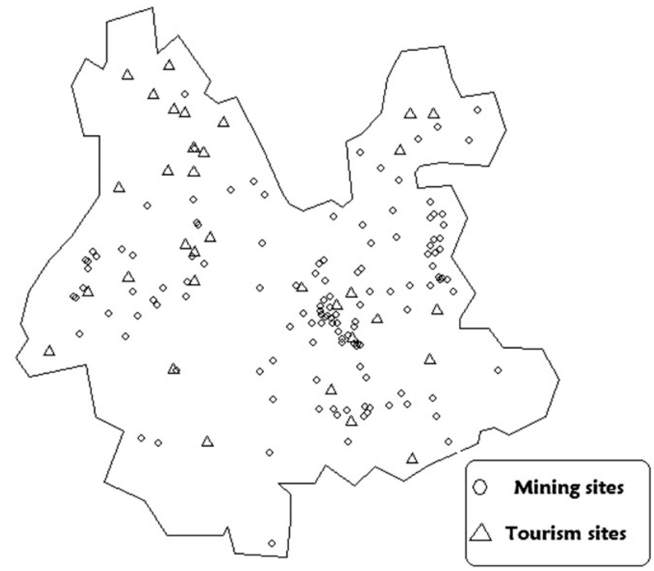

Fig. 4. Mining and tourism sites in Yunnan. Note: The boundary of Yunnan province was adjusted to reduce the accuracy of mining sites' location, which was part of the agreement for the authors to attain the mining sites' map.

a population of about 43.8 million people (Yunnan Statistics Bureau, 2009). Yunnan hosts the "mountains of southwest China" biodiversity hotspot. Yunnan is the habitat for 59.4% of the protected wild animals, 62.9% of the flora and 60% of the vertebrates in China (Liu et al., 2003). It is also recognized as one of the World Wildlife Fund's Global 200 Ecoregions (2007). In the meanwhile, it is one of the poorest provinces in China. In 2008, 5.55 million people, 12.22% of the population, live below the national poverty line, which is an annual income of USD 175 per capita (Yunnan Statistics Bureau, 2009). The average per capita income was USD 454 in rural areas and USD 1939 in urban areas (Yunnan Statistics Bureau, 2009).

Mining and tourism in Yunnan have been growing at a rate of 20–30% since 1998, when the logging ban was implemented and cut off one of the main income sources (Yunnan Statistics Bureau, 2009). The gross domestic production (GDP) was USD 83.4 billion (Yunnan Statistics Bureau, 2009). Mining industry takes up about 11% of the GDP (interviews with local officials). In 2003, there were 7119 mines in Yunnan. More than 80 mineral resources, including coal, iron, manganese, copper, lead, zinc, tin, gold, phosphorus and cement are being explored in Yunnan. Mining industry provided 349,800 jobs in Yunnan (Mining Management Unit Yunnan Land Resource Administration, 2004). The total sale production value in 2003 was USD 12.86 billion with a profit of USD 0.55 billion (Mining Management Unit Yunnan Land Resource Administration, 2004). Tourism in Yunnan has experienced rapid growth since the early 1990s (Fig. 3). Tourism attractions in Yunnan include tropical forest, Karst geographic phenomenon, ancient towns, and diverse cultures from ethnic groups. In 2008, there were 107.6 million tourism visits and the tourism receipts were USD 9.71 billion (Yunnan Statistics Bureau, 2009). Severe poverty, rich biodiversity, and the prosperity of mining and tourism make Yunnan an ideal study area to explore our research questions.

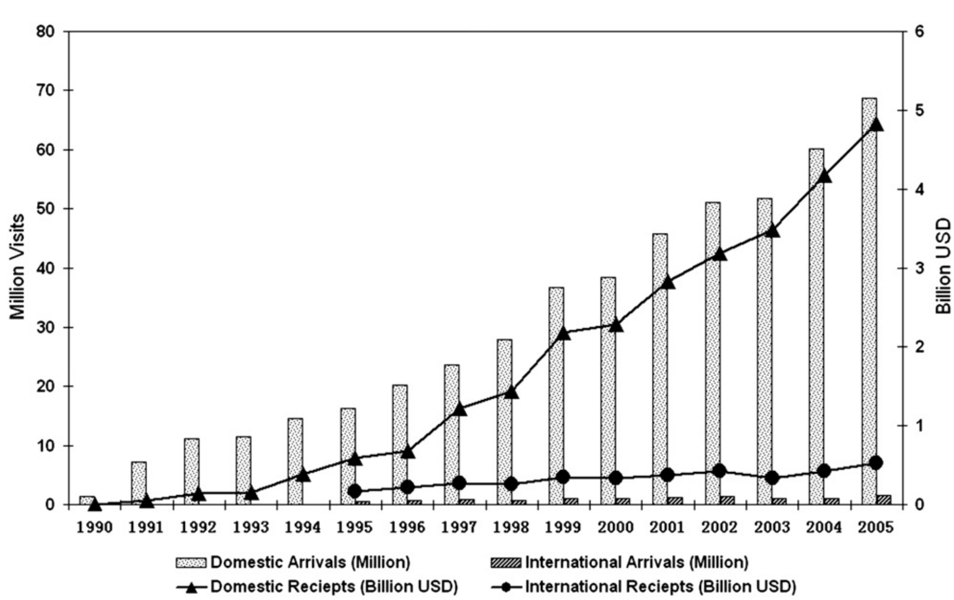

Fig. 3. Tourism growths in Yunnan 1990–2005.

3. Method

3.1. Data

Prefecture, an administrative unit under province, was used as the analysis unit to examine the economic contributions of mining and tourism. There are 16 prefectures in Yunnan. We used international tourist visit (ITV) and mining production value (MPV) to measure the economic contributions of tourism and mining respectively. ITV measures how many foreign people come to visit each prefecture during a year. It is regarded as a good proxy indicator for the size and economic contribution of local tourism development (Sun et al., 2008). MPV is the sum of production values of coal, ferrous metal, nonferrous metal and nonmetal minerals. It is the best measurement of mining activities available at the prefecture scale. Gross domestic production (GDP) was used to describe local economic development. All three variables, ITV, MPV and GDP are from the annual statistic book of Yunnan (Yunnan Statistic Bureau, 1999, 2003, 2005).

The locations of tourism and mining sites were digitized in ArcGIS™ 9.2 from hard copy maps. Map of mining sites was obtained from the Land and Resource Department, Yunnan Provincial Government (2003). It included 129 large or medium mines (Fig. 4). Map of tourism sites was obtained from Yunnan Tourism Administration as an attachment of the master plan of tourism development in Yunnan (WTO et al., 2004). It included 33 major tourism attractions (Fig. 4).

3.2. Correlation Analyses of Economic Contributions of Tourism and Mining

We used three years of MPV, ITV and GDP (Yunnan Statistic Bureau, 1999, 2003, 2005) to increase the sample size from 16 to 48. Kunming, the capital of Yunnan, is very well developed relative to the rest areas and stands as an outlier with extremely high MPV, ITV and GDP (Fig. 5). Furthermore, the sample (with or without Kunming) was not normally distributed (Figs. 5 and 6). Taking these into account, both parametric and nonparametric correlation analyses (specifically, Spearman correlation analysis) were conducted in SPSS Statistics 18 among ITV, MPV and GDP to examine their relationship. Log transformation was analyzed for comparison purposes. Because nonparametric correlation only considers the order instead of the absolute value of each variable, transforming variables into log form would not change the nonparametric correlation relationship. All the correlation analyses were conducted using both the full datasets of 48 samples and the dataset of 45 samples excluding Kunming for all three years.

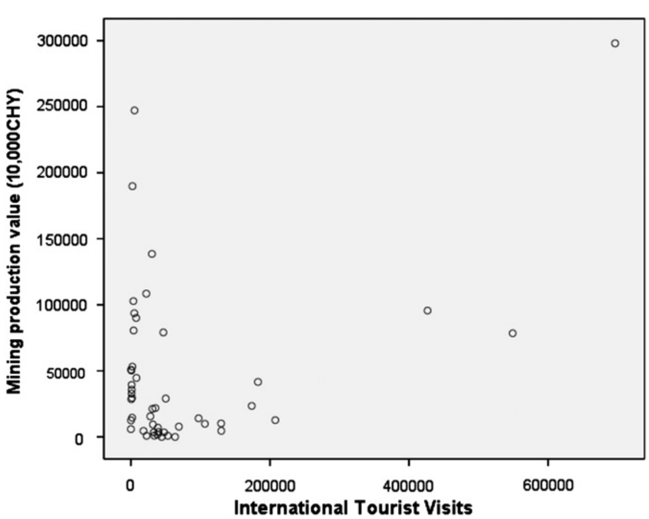

Fig. 5. Mining production values and international tourist visits of prefectures in Yunnan 1999, 2003 and 2005. Kunming is at the far upper right corner indicating its extremely high values for both variables compared with the rest of Yunnan province.

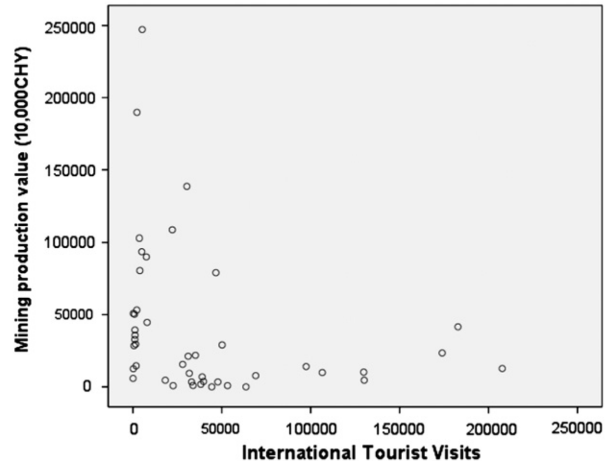

Fig. 6. Mining production values and international tourist visits of prefectures in Yunnan 1999, 2003 and 2005 excluding Kunming.

3.3. Spatial Patterns of Tourism and Mining Sites

We analyzed the spatial patterns of tourism and mining sites to examine whether these two industries were spatially clustered, or inhibited. Tourism and mining sites are coexisting in the study region. Consequently, we can view the complete set of data as a bivariate spatial point pattern, and investigate the possible dependence between the two types of sites (Andersen, 1992; Harkness and Isham, 1983). The question of interest was whether tourism and mining sites could have arisen from a homogeneous Poisson process, that is, the sites are distributed randomly within the study region. Alternatively, these sites interact directly with each other, either clustering together or inhibiting each other.

Various methods have been employed to investigate mapped point patterns (Diggle, 1983; Gatrell et al., 1996; Baddeley and Turner, 2005). In this study, the bivariate nearest neighbor distribution function $G_{12}(d)$ was employed to investigate the nature of any dependency between mining and tourism sites (Diggle, 1983). The $G_{12}(d)$ function is a distance-based approach, and has been widely used for analysis of mapped spatial point pattern (e.g., Baddeley and Turner, 2005; Li and Zhang, 2007). The distribution function of $G_{12}(d)$ can be defined as (Diggle, 1983):

$$G_{12}(d) = P\,\{\text{distance from an arbitrary type 1 event to the nearest type 2 event is at most d}\}. \tag{1}$$

The empirical distribution function (EDF) of the nearest neighbor distances, $\hat{G}_{12}(d)$, were used to estimate the $G_{12}(d)$. We used $\hat{G}_{12}(d)$, rather than the theoretical EDF of the $G_{12}(d)$ because: 1) the theoretical EDF of the $G_{12}(d)$ is approximate, and 2) more importantly, the bias introduced by edge effects could be eliminated when using the $\hat{G}_{12}(d)$ (Diggle, 1983).

We used Monte Carlo simulation techniques to calculate the EDF of the $\hat{G}_{12}(d)$, and to test the significance of the independence between mining sites and tourism (Baddeley and Turner, 2005; Diggle, 1983). Specifically, we first generated 99 independent simulations of complete spatial randomness with the same intensity of the point pattern of the observed data (i.e., mining or tourism sites) in the study region. We then calculated the EDF of the $\hat{G}_{12}(d)$ for each of the 99 simulations, and $G_{12}(d)$, the mean of the 99 simulated EDFs of the $\hat{G}_{12}(d)$. We also used the maximum and minimum of these functions from the simulated patterns to define the upper and lower

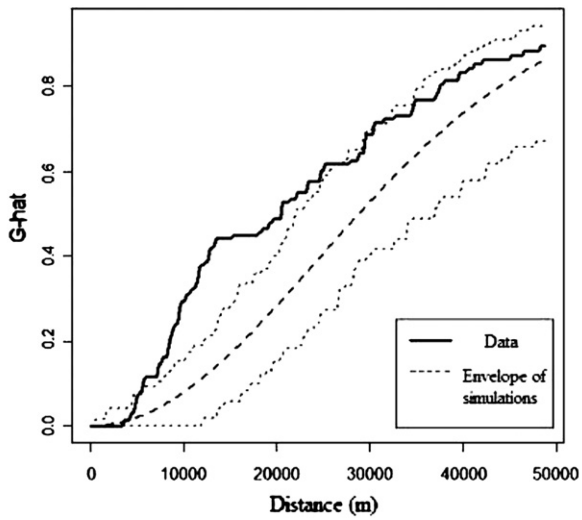

Fig. 7. Empirical distribution function plot of nearest neighbor distances for mining sites, together with the upper and lower envelopes from 99 simulations of complete spatial randomness.

simulation envelopes. A test then was conducted by plotting out the EDF of the $\hat{G}_{12}(d)$ of the observed data against the sample mean of the 99 simulated EDFs of the $\hat{G}_{12}(d)$, and the upper and lower simulation envelopes from the simulated EDFs (Fig. 7). The calculations and simulations of those functions were performed using the package Spatstat in R (Baddeley and Turner, 2005).

4. Results

4.1. Correlations Among MPV, ITV and GDP

As shown in Table 1, MPV was positively correlated with GDP at the 99% confidence level in all the correlations. The relationships of ITV with MPV and GDP depended on whether Kunming was included in the analysis or not. When Kunming was included, most correlation coefficients of ITV and MPV or GDP were positive and a few of them were significant at the 99% confidence level (Table 1). When Kunming was excluded, ITV was reported to be negatively correlated with GDP or MPV. The confidence level was 99% of the nonparametric correlation between ITV and GDP. The confidence level for parametric correlations between ITV and GDP were all lower than 95%, although two of the four were higher than 90% (i.e. 94.5% for correlation of log ITV and GDP, and 91.7% for correlation of log ITV and log GDP). The confidence level for correlation between ITV and MPV were significant at 95% when both variables are in log forms and at 99% for the nonparametric correlation.

Table 1
Parametric and Nonparametric Correlations among MPV, ITV, and GDP.

	Exclude KM as an outlier?		MPV~GDP	ITV~GDP	MPV~ITV
Parametric correlations	No.	Coefficient	.766**	.751**	.399*
	N = 48	Sig. (2-tailed)	<.001	<.001	.005
	Yes.	Coefficient	.767**	−.241	−.292
	N = 45	Sig. (2-tailed)	<.001	.111	.052
Parametric correlations in log form	No.	Coefficient	.766**	.751**	.399*
	N = 48	Sig. (2-tailed)	<.001	<.001	.005
	Yes.	Coefficient	.767**	−.241	−.292
	N = 45	Sig. (2-tailed)	<.001	.111	.052
Nonparametric correlations	No.	Coefficient	.660**	−.119	−.223
	N = 48	Sig. (2-tailed)	<.001	.421	.128
	Yes.	Coefficient	.605**	−.358**	−.431**
	N = 45	Sig. (2-tailed)	<.001	<.001	<.001

4.2. Spatial Patterns of Tourism and Mining Sites

Our results indicated positive dependence (i.e., clustering) between mining and tourism sites. The EDF plot of the "cross-type" (i.e., mining to tourism) shows that $\hat{G}_{12}(d)$ from observed data lies mostly above $\overline{G}_{12}(d)$, the sample mean of the 99 simulated EDFs (Fig. 7). This suggests that mining sites tend to cluster with tourism sites. $\hat{G}_{12}(d)$ lies above the upper envelope at the distance range of 25 km to 45 km, the distance scale at which mining sites and tourism sites clustered (Fig. 7).

5. Discussion

5.1. Correlations Among Mining, Tourism and GDP

MPV is positively correlated with GDP at the 99% significant level in all the analysis. The positive correlation between MPV and GDP indicates that active mining activities usually occur in the relatively fluent prefectures. This finding is consistent with the general conception held by local officials that mining industry contributes to local economy (interviews with local officials). Since correlation analysis itself does not indicate causality, this positive correlation could be explained as either rich prefectures tend to invest in and thus have more mining activities, or the other way around, that is, mining activities tend to bring more income to the prefectures. Through interviews with local officials in the land and resource department of Yunnan province, we learned that mining development requires little investment from the government side. Instead, taxes from granting the exploration and mining rights to companies constitute a considerable part of government revenue. Therefore, it is reasonable to interpret the positive correlation relationship between GDP and MPV as mining activities have a significant contribution to local economy.

When we considered the correlation relationships involving ITV, whether Kunming was included in the dataset played a role. Kunming is an extreme outliner with exceptional high values for GDP, MPV and ITV. Including Kunming into the dataset changed the correlations for all the 16 prefectures. Therefore, the correlation results from the dataset excluding Kunming (N = 45) describe the pattern of mining and tourism in Yunnan better than that from the entire dataset.

The results from the dataset excluding Kunming (N = 45) indicated that tourism is better developed in places where mining (measured by MPV), or in general, economy (measured by GDP), is less developed. The correlation analysis itself does not imply causality and works best for exploratory purpose. Therefore, this result cannot be simply interpreted as tourism development would harm GDP or mining growth, or mining development or GDP growth would impede tourism growth. How and why tourism development is associated with relatively low GDP and less developed mining industry in Yunnan needs more research. Based on the fieldwork experience and interviews with local officials in Yunnan, the following two things would be worth exploring in the further studies. First, although Yunnan has a variety of tourism resources including historical sites, tropical forests, exotic cultures and geographical spectacles, pristine tourism constitutes a large portion. Many tourists are attracted by the original lifestyle and the intact natural beauty. Therefore, a large proportion of tourism grows in the least developed areas in Yunnan.

Secondly, mining sites sometimes do have a negative impact on tourism development. Most visitors are attracted by the undisturbed nature and exotic culture of Yunnan. They expect to enjoy a pristine nature and culture and want to avoid any sign of the modern world during their trip. Mining activities would destroy the trip not only by reminding people about the modern life but also making it physically unpleasant for visitors due to the associated noises, waste and its open air working landscape.

5.2. Spatial Patterns of Tourism and Mining Sites

The fact that mining and tourism cluster could be a result of either tourism tending to be close to a mine or mining tending to occur nearby a tourism attraction or both. Except for mining heritage tourism (which does not exist in Yunnan), such cluster is contrary to the general intuition that tourism would stay away to a mine, but it could be explained by the following three reasons. First, large and medium scale mines require convenient accessibility. Tourism developer has an incentive to have new attraction close to roads to reduce infrastructure construction expense. Mining in Yunnan has a history of 3000 years (Zhang, 2000) whereas tourism started to grow since 1990. Although our study used static data, it is generally safe to regard tourism as “new comer”. Therefore, tourism sites may be built around mines in order to share the existed road and other infrastructure.

Secondly, local government usually has to invest in the initial tourism development or to improve infrastructure to attract investors and developers. Poverty is widespread in Yunnan and many local governments rely on provincial and central governments to cover their basic budget. Mining contributes a lot to local taxation. Those local governments receiving taxes from mining activities are more likely (if they are not the only few) to be able to invest and support initial tourism development. Thus, tourism attractions usually locate in the same prefectures with mines.

Finally, there might be another variable associated with tourism attracting mining activities. Geography provides one example. Yunnan has quite a few geographic spectacles as tourism sites such as the Nujiang Valley, the Three Parallel Rivers World Heritage and the Stone Forest. They all came from complicated geologic processes which may also result in mineral reserves as well. For example, a large copper reserve was explored in the same area with the Three Parallel Rivers World Heritage in 2006 (Yang, 2006).

Incorporating results from both correlation analyses and spatial patterns generate an interesting finding. Although mining favors fluent areas while tourism prefers less developed areas when measured by economic dimensions (i.e. MPV, ITV and GDP), the locations of mining and tourism sites tend to be close to each other. Such results indicated that the tourism sites nearby mining activities are probably less attractive or profitable compared with tourism sites away from mining activities.

5.3. Implications at the Global Scale

Putting findings from this study of one biodiversity hotspot onto the global scale generated some interesting discussions. Our study indicated that, in Yunnan, mining industry tends to occur in relatively fluent areas because of its contribution to local economy. However, the study area, Yunnan is one of the poorest provinces in China. This is consistent with the economic pattern of mining at the global scale that mining activities occur mostly in relative poor regions, with only areas surrounding the mining sites being the “relatively rich” spots in these regions. Abundance of mineral resources may bring an opportunity to reduce poverty (Shen and Gunson, 2006), but it may also lead to the path of “resource curse”. “Resource curse” refers to the phenomenon that over time countries and regions with abundant mineral resources may have less economic growth and worse development outcomes than those with fewer natural resources (Power, 1996; Davis, 1998; Auth, 1993, 1991, 1998; Gelb, 1988; Kremers, 1986). Globally, most biodiversity hotspots are experiencing severe poverty and have abundant mineral resource. While mining may reduce poverty directly by creating jobs, how mining can lead to healthy and sustainable economic growth, and also to conserve the biodiversity, remain challenging in these hotspots.

This study also found out that tourism tends to occur in less developed areas in Yunnan. It is consistent with the finding at the global scale that tourism is growing much faster in the developing world (Deloitte and Touche, 1999; Christ et al., 2003). This growth pattern and the rise of ecotourism bring an opportunity for developing areas to reduce poverty and conserve biodiversity through tourism development. Many studies have shown that with careful design (i.e. local community's participation, transparent benefit-sharing mechanism, etc.), tourism bears a great potential to bring in continuous income without sacrificing the environment (Ashley et al., 2001; Roe et al., 2004; Bjork, 2000; Deloitte and Touche, 1999.

Our study indicated that tourism sites close to mines are less profitable compared with those far away from mining activities. The interaction between mining and tourism has not been studied extensively at the global scale. One conflict that has been recognized is the land use conflict between the two industries. Whether our finding could be applicable in other regions or at the global scale requires future research.

5.4. Limitations

This research has several limitations. First, MPV, ITV and GDP were not the best measurements of mining, tourism and general economic welling of an area. Due to limited data availability, mining and tourism development were both measured by proxy indicators, i.e. major mineral production values and international tourist visits. Although they are widely used to describe the development of the two industries, they are not the most direct and comparable measurements of mining and tourism such as proportion of GDP generated by mining or tourism, which are not available at the scale of this study. GDP was used to describe general economic wellbeing of an area. Many studies showed that GDP does not measure the social welling or the quality of life properly (Costanza et al., 2007). Including more social indicators will help to present a full image of the study area and bring more insights on how mining and tourism development associated with the wellbeing of an area.

Secondly, although data from three years (1999, 2003 and 2005) were included in this study, the analysis was static as all the data were included in one dataset to increase the sample size. If more data were available, a temporal analysis would be very helpful to examine how the relationship among mining, tourism and the overall socioeconomic wellbeing of an area changes over time. This would help to articulate the question that whether mining sites chose to be nearby a tourism site or the other way around when discussing the phenomenon that mining and tourism sites cluster.

Finally, we only considered direct distance when we conducted the spatial pattern analysis and did not take the road accessibility into account due to data availability. This may generate spurious “aggregation” results as the distance in reality from one site to another could be much greater than the direct distance.

6. Summary and Conclusions

Nowadays many mining activities and tourism growth are occurring in biodiversity intense areas globally. How to manage and balance these two industries on issues such as land use depends on our understanding of the nature of mining and tourism and the way they interact with each other. This study examined mining and tourism in Yunnan, China, one of the 34 biodiversity hotspots in the world through the lens of economic contribution and spatial arrangement. Results showed that mining activities tend to be in relatively fluent areas while tourism tends to occur in less developed areas when measured by economic indicators. Mining industries contribute significantly to local economy. Although the entire region is poor, areas around mining sites are relatively fluent. The physical locations of mines and tourism sites are clustered. However, the two industries usually perform better economically when they are apart from each other. This divergence is worth further study to investigate what impedes mining or tourism growth when they are close to each other.

Based on these findings, in biodiversity rich areas with existing mining activities, we recommend considering mining industry as an important supplement to the economy in a long term. Close attention should be paid to the volatile nature of their mineral resources, and the adverse impacts of mining on biodiversity conservation. In addition, revenues from mining should be invested in economic activities that would reduce poverty and conserve biodiversity. Tourism, when designed with local people and the environment in mind, has great potential in bringing income to poor areas without destroying the environment. Therefore, it can serve as a channel to reduce poverty and save biodiversity. However, conflicts between tourism and mining exist when they occur in the same area as tourism income is impacted by mines nearby. Depending on the development stage of the two industries (i.e. how much mineral resource is left, and how mature the tourism is) and the local economy (how important mining income is), choice of favoring mining income for poverty relief or tourism aiming at long-term sustainable development has to be made.

Acknowledgments

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References

Andersen, M., 1992. Spatial analysis of two-species interactions. Oecologia 91, 134–140.

Arabsheibani, G.R., Labarthe, A.D., 2002. The economic impact of tourism in Peru. The Brazilian Journal of Business Economics. 2 (3), 31–43.

Ashley, C., Roe, D., Goodwin, H., 2001. Pro-poor tourism strategies: making tourism work for the poor. Overseas Development Institute, Centre for Responsible Tourism, and International Institute for Environment and Development.

Auth, R.M., 1991. Mismanaged mineral dependence: Zambia 1970–90. Resource Policy 17 (3), 179–183.

Auth, R.L., 1993. Sustaining Development in Mineral Economies: the Resource Curse Thesis. Routledge, New York.

Auth, R.M., 1998. Mineral wealth and the economic transition: Kazakstan. Resource Policy 24 (4), 241–249.

Baddeley, A., Turner, R., 2005. Spatstat: an R package for analyzing spatial point patterns. Journal of Statistical Software 12, 1–42.

Bjork, P., 2000. Ecotourism from a conceptual perspective: an extended definition of a unique tourism form. International Journal of Tourism Research 2, 189–202.

Brandon, K., 1996. Ecotourism and Conservation: a Review of Key Issues. Environment Department Paper, 33. The World Bank, Washington, DC.

Bridge, G., 2004. Contested terrain: mining and the environment. Annual Review of Environment and Resources 29, 205–259.

Butter, R.W., 1980. The concept of a tourist area cycle of evolution: implications for management of resources. Canadian Geographer 24 (1), 5–12.

Christ, C., Hillel, O., Matus, S., Sweeting, J. 2003. Tourism and biodiversity: Mapping tourism's global footprint. Conservation International and United Nation Environment Programme.

Cincotta, R.P., Wisnewski, J., Engelman, R., 2000. Human population in the biodiversity hotspots. Nature 404, 990–992.

Costanza, R., Fisher, B., Ali, S., Beer, C., Bond, L., Boumans, R., Danigelis, N.L., Dickinson, J., Elliott, C., Farley, J., Gayer, D.E., Glenn, L.M., Hudspeth, T., Mahoney, D., McCahill, L., McIntosh, B., Reed, B., Abu Turab Rizvi, S., Rizzo, D.M., Simpatico, T., Snapp, R., 2007. Quality of life: an approach integrating opportunities, human needs, and subjective well-being. Ecological Economics 61 (2–3), 267–276.

Davis, G.A., 1998. Learning to love the Dutch disease: evidence from mineral economies. World Development 23, 1766–1779.

Deloitte and Touche, International Institute for Environment and Development and Overseas Development Institute, 1999. Sustainable Tourism and Poverty Alleviation. Report to the U.K. Department for International Development.

Diggle, P.J., 1983. Statistical Analysis of Spatial Point Patterns. Academic Press, London.

Fisher, B., Christopher, T., 2007. Poverty and biodiversity: measuring the overlap of human poverty and the biodiversity hotspots. Ecological Economics 62, 93–101.

Gatrell, A.C., Bailey, T.C., Diggle, P.J., Rowlingson, B.S., 1996. Spatial point pattern analysis and its application in geographical epidemiology. Transactions of the Institute of British Geographers 21 (1), 256–274.

Gelb, B., 1988. Oil Windfalls: Blessing or Curse? Oxford Univ. Press. London, World Bank.

Harkness, R.D., Isham, V., 1983. A bivariate spatial point pattern of ants nests. Applied Statistics 32, 293–303.

Ironside, R.G., 2000. Canadian northern settlements: top–down and bottom–up influences. Geografiska Annaler. Series B, Human Geography 82 (2):Development of Settlement. 103–114.

Kremers, J., 1986. The Dutch disease in the Netherlands. In: Neary, J.P., van Wijnbergen, S. (Eds.), Natural Resources and the Macroeconomu. MIT Press, Cambridge, MA, pp. 96–136.

Land and Resource Department, Yunnan Provincial Government, 2003. Comprehensive plan of mining resources in Yunnan province: 2000–2010.

Li, F., Zhang, L., 2007. Comparison of point pattern analysis methods for classifying the spatial distributions of spruce-fir stands in the north-east USA. Forestry 80 (3), 337–349.

Liu, S., Liu, J., Luo, M., Wang, Y., 2003. Study on the problems of the national natural reserves in Yunnan. Problems of Forestry Economics 23 (3), 147–152.

Malcolm, J.R., Liu, C., Neilson, R.P., Hansen, L., Hannah, L., 2006. Global warming and extinctions of endemic species from biodiversity hotspots. Conservation Biology 20 (2), 538–548.

Sinclair Knight Merz, 2000. Planning for the Gingin Coast No. 5 land capability. Draft working paper summary.

Mining Management Unit Yunnan Land Resource Administration, 2004.

Miranda, M., Burris, P., Bingcang, J.F., Shearman, P., Briones, J.O., Vina, A.L., Menard, S., 2003. Mining and Critical Ecosystems: Mapping the Risks. World Resources Institute, Washington DC.

Myers, N., Mittermeier, R.A., Mittermeier, C.G., da Fonseca, G.A.B., Kent, J., 2000. Biodiversity hotspots for conservation priorities. Nature 403, 853–858.

Power, T.M., 1996. Lost Landscapes and Failed Economies: the Search for a Value of Place. Island Press, Washington, DC.

Roe, D., Goodwin, H., Ashley, C., 2004. Pro-poor tourism: benefiting the poor. In: Singh, T.V. (Ed.), New Horizons in Tourism, Strange Experiences and Stranger Practices. CABI, pp. 147–162.

Sachs, J.D., Baillie, J.E.M., Sutherland, W.J., Armsworth, P.R., Ash, N., Beddington, J., Blackburn, T.M., et al., 2009. Biodiversity conservation and the millennium development goals. Science 325 (5947), 1502–1503.

Shen, L., Gunson, A.J., 2006. The role of artisanal and small-scale mining in China's economy. Journal of Cleaner Production 14 (3–4), 427–435.

Smith, R.J., Muir, R.D.J., Walpole, M.J., Balmford, A., Leader-Williams, N., 2003. Governance and the loss of biodiversity. Nature 426, 67–70.

Sun, G., Yafen Han, Y., Yu, L., 2008. A study on relationship between foreign openness degree and inbound tourism development in China. International Journal of Business and management. 3 (1), 62–69.

Temu, A.E., Due, J.M., 2000. The business environment in Tanzania after socialism: Challenges of reforming banks, parastatals, taxation and the civil service. The Journal of Modern African Studies 38 (4), 683–712.

The World Bank, 2004. HIV/AIDS and mining. http://www.worldbank.org/ogmc/wbminingaids.htm. Retrieved on Oct, 27 2005 from.

Weigend, G.G., 1985. Economic activity patterns in White Namibia. Geographical Review 75 (4), 462–481.

World Tourism Organization (WTO), Yunnan Provincial Tourism Administration and China National Tourism Administration, 2004. Master Plan of Tourism Development in Yunnan Province. Yunnan University Press, Kunming, China.

World Travel and Tourism Council (WTTC) and International Hotel & Restaurant Association (IHRA), 1999. The Global Importance of Tourism. Background paper no. 1, prepared for the commission on sustainable development, seventh session, 19–30 April 1999.

World Wildlife Fund, 2007. Global 200 Ecoregions. http://worldwildlife.org/science/ecoregions/palearctic.cfm. Webpage. Retrieved on Apr 30, 2006 from.

Yang, M., 2006. Yunnan suggests redrawing boundary of Three Parallel Rivers heritage site. Nanfeng Chuang. Oct 16, 2006. http://www.probeinternational.org/three-gorges-probe/yunnan-suggests-redrawing-boundary-three-parallel-rivers-heritage-site. Retrieved online on Nov 17, 2010.

Yunnan Statistics Bureau, 1999, 2003, 2005. Yunnan annual statistical book 1999, 2003, 2005. China Statistics Press, Beijing.

Yunnan Statistics Bureau, 2009. Yunnan Statistical Annual Report 2008. China Statistics Press, Beijing.

Zhang, Z., 2000. Yunnan Metallurgy History. Yunnan Fine Art Publishing House, Kunming, China.