Governing the commons: A case study of the Tricholoma matsutake resource management*

Zhou Jianhua

School of economics and management, Beijing Forestry University

P.O Box 39#, 35 Qinghua Dong Lu, Haidian, Beijing, P.R. China 100083

zjh296@gmail.com

Abstract: Hardin's seminal paper presents a tragedy of the commons, that is, rationality to individuals sometimes causes irrational result to the society, which is widely confirmed with our observations. How to avoid the Tragedy of the Commons? There are three different policy proposals: using the public ownership, and providing public goods and public resources management through a strong central government; privatization, enhanced by clear property rights, exclusive to reduce over-utilization of resources; through community cooperation to achieve sustainable use of public resources . In this paper, a case on the sustainable Tricholoma matsutake management in the Baimaxueshan Nature Reserve in Yunnan Province is presented. It describes the current problems existing in the utilization of the Tricholoma matsutake resources, introduces the practices of the sustainable Tricholoma matsutake management for matsutake and finally points out the conditions in achieving success community governing the common pool resources and avoiding the tragedy of the commons.

Key words: Common pool resources; Tricholoma matsutake; poverty alleviation; sustainable management

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1. Introduction

Since 1968, when Hardin publishes his seminal paper in Science the concept o the tragedy of the commons has been well known. It said that in an open access environment, as long as many of the common use of a scarce resource, it will lead to environmental degradation. He explained that in a society of believing in free use of public lands, individual's rational self interest-seeking behavior will lead to tragic result for the whole community (Hardin, 1968). The phenomena of the tragedy of the commons are widespread in the world and we observe them almost everywhere: the degradation caused by overgrazing; over-fishing led to the fisheries depletion; excessive extraction of groundwater and so on. On the issue of how to avoid the tragedy of the commons, there were a variety of policy options: one thinks that the individuals would not be interested in the conservation of public land, so we need to put the natural resources system under the control of a strong central government (Hardin, 1978; Heilbroner, 1974) ; the second array to the policy choice goes to the opposite direction. It affirms that the only approach to avoid the tragedy is to enhance the private property rights system in any places where resources belong to the public (Demsetz, 1967; Smith, 1981); Ostrom (1990) proposed a third solution through the self-organizing and self-governance policies of public resources, that is a compromise policy of the first two policies.

In this paper, with the case study of sustainable Tricholoma matsutake management in the Baimaxueshan Nature Reserve, I try to analyze the adaptability of self-governance model and the conditions required for a success practice. Tricholoma matsutake is a kind of non-timber forest product (NTFP). In the public, it can be harvested with open access, and it is a typical common pool resource with the characteristics of competitiveness and non-exclusiveness.

Tricholoma matsutake is kind of mushroom, with high economic value, and it is an important NTFP in natural forests. In 1999, it was assigned as the second-class protected plant by the State Council of China. In China, Tricholoma Matsutake grow in Heilongjiang, Jilin, Yunnan, Sichuan, Tibet and several other provinces, of which Yunnan is the most important producing areas in China, which accounts for more than 50% of the production in weight. The Tricholoma Matsutake is a symbiotic bacteria and it must live in the living host tree roots. The Tricholoma Matsutake has a tendency in selecting host trees, and the host trees in in different regions are generally different. Tricholoma Matsutake in Yunnan Province grow at the area

with deep humus of the neutral soil in the forest mixed with temperate and cold temperate Yunnan pine, Huashan pine and oak trees, azaleas at an altitude of 1600-3200 meters. The mushroom spores fall to the ground, and grow with fibrous root of tree. Then they gradually form a mycorrhizae, which takes the shape of mushroom circle, also known as "Mushroom pond". The mushroom can grow and harvest during the June and the early November, and the peak harvest occurs at August and September. The environment requirements for the Tricholoma Matsutake growing are quite strict and its harvest also needs to reach a certain requirements in harvest. Mycorrhizae should not be destroyed, otherwise its growth will be undermined. Generally, the iron spade is inappropriate in harvesting, and the humus should not be scratched and spoiled. However, in the open access scenario, those rules can not be obeyed completely.

The Tricholoma Matsutake harvested in China are mainly exported to Japan, who has a long history in the Tricholoma Matsutake consumption, and Japan is the main consumer of Tricholoma Matsutake in the world. As Japan's Tricholoma Matsutake production declined sharply since 1980, it began to import Tricholoma Matsutake from other countries. Currently, Japan imports Tricholoma Matsutake from more than 10 countries, the majors ones are China, South Korea, North Korea and Canada. It is estimated that the Tricholoma Matsutake traded in Japan account for 95% production of the world (Gong and Wang, 2004).

Table 1：The trand of the Tricholoma Matsutake imported in Japan

Year	1995	1996	1997	1998	1999	2001
Total Imported（ton）	3515	2703	3059	3248	2935	2394
Imported from China（ton）	1191	1152	1076	1313	1292	1531
%of from China	33.88	42.62	63.42	84.79	72.02	80.28

Source: Gong and Wang, 2004

Table 1 shows that, from 1995 to 2001, China exported more than 1000 tons of Tricholoma Matsutake to Japan each year. And the Tricholoma Matsutake from China has the lion’s share, over 70% in the total weight, in Japanese market. However, the increase export of Tricholoma matsutake is sustained by the expansion of the harvesting region as well as over harvesting of

Tricholoma Matsutake resources. Generally, the young and the over-matured Tricholoma Matsutake should not be harvested. Because young Tricholoma matsutake gains low price, light weight, low economic value, and harvesting over-matured Tricholoma matsutake can reduce the opportunity of dissemination of spores, which have negative impacts on the future Tricholoma matsutake production. Both the harvesting of the young and the over-matured Tricholoma matsutake have damage to China's Tricholoma matsutake production. However, in China, young and over-matured Tricholoma Matsutakes consist of quite high percentage in the total production. According to statistics, Tricholoma matsutake exported to Japan from Yunnan province, the young Tricholoma matsutake was about 30-40%, and the percentage of over-matured was also quite high. The high percentage of young and over-matured Tricholoma Matsutake caused the low price in the market. For example, in the Japanese market, Tricholoma Matsutake from China received much lower price than that from Korea. On the average, price of the Tricholoma Matsutake from China was equivalent to only 44.2% of that from Korea (Gong and Wang, 2004). The low quality of the Tricholoma Matsutake harvested combined with some other factors such as poor package and species difference contribute for the low price of Chinese Tricholoma Matsutake.

Because of the over-harvesting and the degradation of its growth habitat, the Tricholoma matsutake harvesting in Yunnan began to decline in the early 2000s. The other mushroom producing areas, such as Heilongjiang, Jilin and Sichuan provinces, are suffering the similar loss. The decline of the Tricholoma matsutake production - not only reduce the income source for local community, but also it reduced the enthusiasm of farmers to protect the forest. Therefore, achieving sustainable use of Tricholoma matsutake resources will be a help to increase households' income, alleviate poverty and protect natural forest resources and biodiversity

2. Case Study in Baimaxueshan Nature Reserve

A case of Tricholoma matsutake resource management, which happened in the neighbor communities of Baimaxushan Nature Reserve, is introduced in this paper. The measures of the management are presented and experiences from the case are summarized. The information in this case is based on the two field surveys, which were taken place in

December 2006 and August to September 2007. The field surveys included village-level participatory assessments (PRA) and household interviews. Because of the inconvenience of the local transportation and language barrier, the surveys received large assistance for the Baimaxueshan Nature Reserve Administration Agency. The PRAs were implemented together with the Nature Reserve staff and the household interview was carried by research team. We interviewed 21 households and participated village level PRA in 9 villages. Besides, the Tricholoma matsutake markets were visited and we have conversations with different stakeholders, including staff from nature reserve, Tricholoma matsutake harvesters and buyers.

2.1 Baimaxueshan Nature Reserve and its local communities

Baimaxueshan Nature Reserve located in Diqing Tibetan Autonomous Prefecture in northwest Yunnan Province. It spreads in Deqin county and Weixi county, with a total area of 281640 hectares, and its altitude varies from 1950m to 5429m. Baimaxueshan Nature reserve was established for protecting snub-nosed monkey and its habitat as well as other wildlife. There are quite a lot population reside in or near the nature reserve and the nature reserve face high pressures and threats from the local communities.

In Deqin county part, there are 8802 persons from 1614 households reside in the nature reserve. These households scattered in 93 nature villages in 8 administrative villages of Benzilan town and Xiaruo township. In the Weixi part, the population resides in the nature reserve is low. In this part, there are 782 persons from 154 households reside in the nature reserve. These household located in 9 nature villages in 5 administrative villages of Tacheng town, Baijixun township and Kangpu township. The Weixi part of the nature reserve was designed in the early 2000s, when the local communities has more awareness on the land right, the government had tried best to avoid covering communities and population in nature reserves. However, the communities and population neigbouring and around the nature reserve are quite large.

Of all the population live in Baimaxueshan Nature Reserve, Tibetans are 7474, accounting for 78.0%. Lisu 883, accounting for 9.2%. These two ethnics are dominant in this area.

The population reside in the nature reserve have high percentage of poverty occurrence. For

example, in the Deqin County, 65% of the population under poverty line resided in nature reserve, while the percentage of population in the nature reserve is 33%. The high poverty occurrence mainly because the poor communication and transportation condition, lack of cropland and the constraint to access natural resource due to the establishment of the nature reserve.

According to the survey conducted in 2004, the communities located in Baimaxueshan Nature Reserve have only 0.105 ha per capita, while the numbers of the Deqin part and Weixi part are 0.095 and 0.114 respectively. In fact, because there are some cropland was converted into forestland after 2004, the cropland in these communities should be less than that from the survey in 2004. According to our survey of 8 nature villages in 2007, the average cropland occupied is 0.078 ha per capita, varying from 0.014 ha to 0.295 ha per capita. The main production activities in these communities are crop planting and livestock raising. The crops mainly include the corn, wheat, barley and buckwheat, and the livestock are mainly the cattle and pigs. The crop yield is very low in this area due to cold weather, inadequate irrigation and low technology. The local communities can not supply sufficient grain for themselves. The average grain production was only 279 kg per capita in the communities in the nature reserve, according to the survey of 2004. The grain production was far below the national average consumption level. About 40% of the villages can only produce two thirds of grains they need. That means they should import grains from other places. Local livestock production is also self-sufficiency, with rare exceptions. The cattle were primarily raised for butter and pigs for pork. The livestock production is also low and the farmers received net income from agriculture. Therefore, they need to find other income generating source for their living. The non-timber forest products harvesting is one of the main income source to most households in this region.

2.2 Tricholoma matsutake harvesting in Baimaxueshan Nature Reserve

Deqin County was ever a log area and timber harvest was the most important income source for the local residents as well as the local government. After the establishment of Baimaxueshan Nature Reserve in 1984, the timber harvesting was banned within protected areas then. The NTFP harvesting became the main income source for local community.

Among these NFTP, Tricholoma matsutake is very important.

It has a long history for the local community harvesting and consuming Tricholoma matsutake. But it was a kind of subsistence harvesting until 1984 when the local marketing cooperative began to acquire dried Tricholoma matsutake. The fresh Tricholoma matsutake was acquired in 1985, and from then the Tricholoma matsutake harvesting became a commercial activity. The fresh Tricholoma matsutake has been exported to Japan since 1988, and from then it become one of the most important income source to local community. In this area, the Tricholoma matsutake grow in the area with altitude 2400 meters to 3200 meters. It has a distribution area of about 227,000 ha of forest pine or oak trees in the nature reserve. Because the forest have not been logged, the nature reserve was a good place for Tricholoma matsutake grow. The forest coverage, forest density and weather indicators are excellent for Tricholoma matsutake, and the yield is very high. Since 1985, the local community can harvest about 100 ton Tricholoma matsutake and it accounts for a high percentage of income for the local community. It is estimated that the Tricholoma matsutake harvesting income account for about 75% of total net income in recent year. Especially after the strict logging ban policy was implemented since 1998. However, over-harvesting has caused the Tricholoma matsutake resource degradation. During the interview, the villagers said that the quantity and quality of Tricholoma matsutake began to decline since the late 1990s. In some place the Tricholoma matsutake habitat was destroyed and can not grow Tricholoma matsutake any more. As the resource degradation, the competition for the scare resource become harsh and sometimes serious conflicts occurred between individuals as well as communities. On the other hand, the Tricholoma matsutake resource degradation also resulted in further pressures to the nature reserve and the realization of the conservation goal.

2.3 Sustainable Tricholoma matsutake resource Management

Because the Tricholoma matsutake resource is so important to the local community, the degradation of Tricholoma matsutake urged people to find approach to protect it and to achieve sustainable use of it. In response to the request from the local communities, the Baimaxueshan Nature Reserve Administration Agency began to implement the integrated conservation and development project (ICDP) with supports from WWF in 2001. Tricholoma

matsutake sustainable management is one of the important contents in the ICDP. The pilot was conducted in 2001 and achieved success. From then, the sustainable management approach was gradually extended to wider area and it has flexible approach according to the local conditions.

It is widely accepted that the degradation of the Tricholoma matsutake resource was mainly caused by following three reasons: first, too many harvesters from other communities crowed to the collective forest and cause over exploit of the resource; second, harvesting of the young the over-matured Tricholoma matsutake speed up the depletion of the resource; third, inappropriate tools and approaches used in harvesting and the Tricholoma matsutake habitat was destroyed.

The sustainable management programs were a series measures adopted in response to these three kinds of problems. With the Nature Reserve Administration Agency's support and coordination, the local communities developed various local regulations and policies to manage the Tricholoma matsutake harvesting and conservation. The major measures can be summarized as follow:

Firstly, each community, usually the administration village, limits the inflow of exotic harvesters to its owned collective forest. Some of the villages set an entrance fee for allowing them to harvest, and the fee were set by each village based on the status of the resources. In the five villages we surveyed, one village completely prohibited exotic harvesters entry, except he or she was former resident of the village and married to other villages. The other four villages all charged a fee for entrance, the fee varied among these villages, from highest of ￥1500 to lowest ￥ 100. Even those villages allow outsiders to come, they also constrained the number of the harvesters, usually only 1-2 persons were allowed for each household. More than the number either prohibited or charge more. For example, the Shusong village only allow 1 person to come for each household outside the village; for Shirong village, harvesters from other county were not permitted to harvest, and the harvesters from other township and other village can be permitted with a charge of ￥300 and ￥100 per person respectively. But only two persons were permitted each household at this charge. If one household have more than three harvesters, each person from the third should be charged ￥500. For the former residents but married to other places, they are generally allowed to

harvest free or just with a small charge.

Second, take measures to avoid the young and over-matured Tricholoma matsutake harvesting. The agreement approved by residents regulated that the young Tricholoma matsutake, which is less than 5 cm in length, and the over-matured Tricholoma matsutake were not allowed to be harvested, otherwise the violators will be fined. In five villages we surveyed, four of them prohibit the young and over-matured Tricholoma matsutake be harvested. The fine to the violators varied. The most severe punishment is in Shiba Village, which set the rules that violators from the village will be fine ￥100 for each young or over-matured Tricholoma matsutake harvested, and the fine will be ￥50 for violators from other villages. Other three villages set a fine varied in the range of ￥3-10 for each. Some villages also set economic punishment to those violators as buyers in addition to harvester.(see Table 2).

Third, the collective agreement also set rules for tools and approaches used in harvesting. The tools such as iron spade, iron hook, which can cut mycorrhizae, were prohibited in harvesting. Besides the tools were regulated, the harvesting approach were also regulated. Those destroying approaches such as dig and roll over the humus were not allowed. Those who violated the regulation would also be fined. The agreement also recommend harvesters to recover the humus layer after harvesting. But it is difficult to monitor such violations. According to the survey (Tibu, et al., 2008), there are two harvest approaches used were harmful currently: the first approach was that the harvester tend to seek in the area with thick humus. When such area was found, the harvester will try to dig the humus to search. Once a piece of Tricholoma matsutake was found, they will dig in carefully the area within 2-4m. This approach will destroy the humus. People use such approach are mainly elderly and children, and they consisted of about 10% total harvesters; The second harmful approach is that the harvesters will not take any measure to protect the “mushroom pond” during the harvesting. About 30% harvesters use such harmful approach. Even though the punish measures were set for the violators, the difficulties in monitoring make such measures helpless. One effective measure to avoid such harmful harvesting approach is training and education and this was demonstrated in some villages.

Fourth, in order to ensure sufficient time for Tricholoma matsutake growing and restoring, most villages set non-harvest schedules. In the surveyed five villages, two villages have a

non-harvest day in every four days, and two have a non-harvest day in every 5 days and the other one village scheduled each Wedesday and Sunday were non-harvesting day. The interval of non-harvesting day were mainly depended on the soil quality and the thickness of humus. Generally, Tricholoma matsutake grow fast on soil with thick humus. One study shows that the daily average growth rate was0.48 cm in length and 0.76 cm in the mushroom cap diameter. The best harvest time was 8-10 days after the Tricholoma matsutake grow from the soil, for in this period, the length of the mushroom is more than 6 cm and it is high quality and weight (Tibu, et al., 2008). Setting the non-harvest day is very important for the Tricholoma matsutake resource restoring, for it can provide time for young Tricholoma matsutake to grow. Typically, people who first discovered the young Tricholoma matsutake and he can hide it and let them grow in non-harvest day without other harvesters find them. The non-harvest day arrangement is helpful for improving the mushroom quality and reducing the harvesting cost.

Fifth, in order to ensure these agreements and regulation to be strictly implemented, the nature reserve administration agency helped the local communities establishing Tricholoma matsutake trade markets in fix locations. All transactions should be completed in the market place at its open time. Generally the market is open at around 5:30 in the afternoon and it last for 2 hours. In the non-harvest day, the markets should be closed. The market management staffs charge each buyer about ￥3-5 as management fee when he entered the market. All transaction should be taken place at the markets at their open time. The violators would be imposed economic penalties. Table 2 shows the measurements in the agreements and regulations in five surveyed villages.

Table 2: Measurements in five surveyed villages

Village	Non-Harvest Time	Monitoring Measures	Exclusiveness	Penalties to violation actions
Shusong	1 day in 5 days	The residents monitor each other on non-harvest day; three nature villages patrol in village forest on non-harvest day as schedule; market staffs	￥1500 for each harvester from other village; only 1 harvester is permitted for each household from other villages; former residents who	￥5 for harvesting each piece of young mushroom; ￥50 for transaction outside the fix market; ￥300 for harvesting on non-harvest day; ￥500 deposit from nature village not be returned if any of its members

		check and supervise the young and over-matured mushroom transaction.	married in other villages themselves were permitted with paying ￥100 for permission.	found harvesting on non-harvest day.
Shirong	1 day in 4 days	The residents monitor each other on non-harvest day; each nature villages patrol in collective-owned forest on non-harvest day as schedule;	No permitting for person from other county；￥300 for each harvester from other township; ￥100 for each harvester from other village; the third and more in a household should pay ￥500 each	￥500 to buyers and ￥200 to seller for transaction outside the fix market; ￥500 once for harvesting on non-harvest day;
Yeri	1 day in 5 days	Two groups of manage the market and patrol the forest; each group has 4 members from each of the nature villages.	No permitting for harvesters from other villages, except the former residents married in other villages.	￥50 for transaction outside the fix market; ￥3 for harvesting each piece of young mushroom and ￥5 for buyers; ￥100 for harvesting on non-harvest day; Deduct ￥300 each time from ￥500 deposit from nature village when any of its members found harvesting on non-harvest day.
Cikatong	1day in 4 days	The leader of each nature village supervises their own village.	￥300 for each harvester from other township; ￥100 for each harvester from other village; former residents married in other villages no charge.	￥5 for harvesting each piece of young mushroom and ￥10 for buyers; ￥50 for transaction outside the fix market; counterfeit the harvesting in non-harvest day.
Shiba	Sunday Wednesday	Patrol by each nature village in sequence.	￥100 for each harvester from other village; ￥20 for each harvester from own village;	￥100 to harvester of the village for harvesting each piece of young mushroom and ￥50 for harvesters from other villages; ￥200 for harvesting on non-harvest day; ￥10 for harvesting each piece of over-matured mushroom

Source: Based on the local agreements

The establishment of a fixed market is an important content in sustainable Tricholoma

matsutake management. The fix markets ensured that all transactions can be made public and the market information open to more public. This will reduce the potential of buyers to control the prices and protect the interests of harvesters. In the same time, in the fix market, the behaviour of harvesting and transacting young and over-matured Tricholoma matsutake were more easily monitored and identified, which is helpful to control the violations on non-harvest day.

The actions of supervising and monitoring various types of violations can be classified into two categories. One is implemented by the community members and the other is enforced by specific group of staffs. Because the nature reserve administration agency has the authority in managing the natural resource, it can serve as a key coordinator among these players, and its participation is essential.. For the individuals and villages generally have diverse interests, the interests conflicts may prevent the agreements adopting.

2.4 The effects and problems in the sustainable Tricholoma matsutake management

Since the pilot practice in 2001, Baimaxueshan Nature Reserve has conducted a series sustainable Tricholoma matsutake management in the local communities in and near the nature reserve. The practices have achieved positive effects, and the approach was adopted by more communities. Though the results of the sustainable management were different, the general results show that the practice of sustainable management was helpful in promoting the Tricholoma matsutake restoring. During the survey, most interviewees gave positive evaluation on such practices. The

and are more community acceptance and use. Although the village is because conditions are different, the results achieved are not the same as, in general, to promote the pine mushroom resource recovery. They were mainly manifested in several ways:

First, Tricholoma matsutake resources been restored, and it provided villagers stable income. In 2006, because the pesticide was found in the Tricholoma matsutake from Yunnan, the price of Tricholoma matsutake fell sharply. However, the income from Tricholoma matsutake harvesting was quite high due to high yield. Of the 21 households we interviewed, 20 of them had Tricholoma matsutake harvesting income, varying from the lowest RMB 1000 to the

highest RMB7000 and with an average of RMB4240. In 2007, the drought caused the Tricholoma matsutake grow late. But the local people were confident to the future, as they thought the Tricholoma matsutake were restored.

Secondly, reduced the harvesting input and cost. Because Tricholoma matsutake harvesting reached its peak during August and September, it overlapped agriculture activities. Before setting the non-harvesting day, many villagers felt helpless for they face the choice between Tricholoma matsutake harvesting and agriculture activities. The non-harvest day not only help to Tricholoma matsutake resources restoration, but also release the harvesters to agriculture activities without worry about the Tricholoma matsutake harvesting.

Thirdly, community cohesiveness strengthened. Before the sustainable management program implemented, the Tricholoma matsutake resources degradation caused the blaming of each other and the competing for the endangered resources caused conflicts. By implementing sustainable Tricholoma matsutake management project, the community member have more communication and have formed the power to act together.

Though it has made some progress in sustainable Tricholoma matsutake resource management, some problems still exist. The most important issue is the difficulties in supervising and monitoring. In some densely populated and relatively convenient traffic areas, such agreements in sustainable management are rarely implemented. For the violate actions can not be easily identified, people have less motivation to abide the agreements they made. So the sustainable management of Tricholoma matsutake in these areas made little progress.

3. Conclusions

From this case study, we know that the community in Baimaxueshan Nature Reserve take the cooperating actions to reduce the damage to Tricholoma matsutake resources, and then restoring them. The success of the case should be attributed to the following factors:

First, the local communities are deeply depended on the income from the forest resources and non-timber forest products. So, they have the motivation to protect the Tricholoma matsutake resource. As mentioned above,, in many communities, the non-timber forest products collecting accounts for 95% of household net income, of which 80% or more is from the Tricholoma matsutake. Thus, the destruction of Tricholoma matsutake resources a great impact for the whole community, they have the power to manage and organize themselves. In

contrast, we see a mushroom management Weixi some communities it is difficult to carry out, one important factor is the dependence of local communities for the mushroom is not high, so the lack of motivation throughout the community.

Second, the success of the implementing the Tricholoma matsutake sustainable management generally occurred in communities with less population, and were inconvenient in communication. Those communities of high population density, traffic convenient area are very difficult to conduct careful monitoring and strict supervision. Third, it is important to have an agency strong executive power during the project implementation process. And the agency should have no interest conflicts with the communities. The existence of such enforcement and coordinating body is a key in ensure the success of the project. In this case, the nature reserveadministration agency played such a role: it has the same objective with local communities in protecting the Tricholoma matsutake resources; it did not involved in Tricholoma matsutake harvesting; it had its interests overriding the Tricholoma matsutake resources; the nature reserve administration agency has a strong executive body, and its management scope covered the whole community. Therefore, nature reserve administration agency can set the fix market, can help the community to punish violation behaviours, can also provide information services for the community.

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