Sustainable livelihoods in a Coptis-planting based rural community: a case study in Shizhu County, China

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Abstract: Coptis chinensis is a medicinal herb used in traditional Chinese medicine. This research features a case study in Shizhu County, China. Participatory Rural Appraisal (PRA) is used as the main tool for data collection. The study demonstrates that the current method of Coptis planting leads to forest destruction. Even with reforestation measures, it leads to the loss of biodiversity in the forest. It also shows that farmers cannot get satisfactory economic returns from Coptis planting, as the return is unstable and unpredictable. One alternative to the current Coptis planting mode is to incorporate it into the agroforestry system. Water shield planting also serves as a good alternative to Coptis planting itself. Improved methods of management, post-harvest processing, and marketing of Coptis are also proposed and analyzed. The intended contribution of this paper to the theoretical debate of sustainability shall be the provision of an example showing how agricultural production affects forest conservation. It also presents redressable measures to the negative consequences. Besides, one alternative livelihood pathway for the rural community in this case study is suggested.

Keywords: Coptis; Forest; PRA; Sustainable livelihood

1 Introduction

Coptis is a genus of flowering plant in the family of Ranunculaceae. The most common Coptis species is called Coptis chinensis, which yields much higher output than any other Coptis species, and it has been planted as an agricultural product for hundreds of years. Coptis chinensis is one of the most important cultivated medicinal plants in China. The rhizome of Coptis chinensis is also called “Huang Lian” in Chinese or “Chinese gold thread” in English. Berberine, a plant alkaloid, is extracted from Huang Lian, and it has demonstrated significant antimicrobial activity against a variety of organisms, including bacteria, viruses, fungi, protozoan [1]. This evergreen perennial prefers slightly acidic soils and moisture. The Coptis land in China are always found to be on the edge of forests, because the current approaches to Coptis planting require cutting forest trees to provide canopies. Due to a long time of unreasonable use of forest resources like mentioned here, together with poor conservation and management, China's forests are of poor quality and weak biological functions, despite that China covers a vast territory [2].

This research focuses on the relationship between the planting of Coptis chinensis and forest conservation, as well as rural livelihood in a Coptis-planting based community in southwestern China. Though the international scientific community has started to show interest on this magical medicinal plant, there have still been very few publications on it so far, possibly due to the very limited plantation distribution of Coptis chinensis in the world. And of all these publications, most focus on its pharmacological properties. Huang and Long's study shows that another Coptis species called Coptis teeta is an endangered species itself, and its incorporation into agroforestry system benefits both conservation and economic objectives [3]. However, the conservational cultivation of Coptis teeta under natural forests in their case is incomparable to my case because the former does not involve cutting trees to provide artificial...
canopies. And comparing to Coptis chinensis, the output of Coptis teeta in China is much smaller [3]. This paper aims to find out how to coordinate the interrelationship of the forest, the rural livelihood, and the Coptis planting at a macro level.

2 Methodology

This study can be characterized as a qualitative research, where a single case in Shizhu County is under comprehensive analysis. The transferability to other settings is the provision of an example showing how the lack of development strategies of an agricultural product can affect forest conservation and livelihoods in rural community.

In any analysis of sustainable livelihoods, the key questions to be asked are similar: given a particular context, what combination of livelihood resources result in the ability to follow what combination of livelihood strategies with what outcome [4]. A range of livelihood resources combined with different livelihood strategies in my case study, including natural, economic, human and social capitals, will be discussed.

The main tool used in the field study is Participatory Rural Appraisal (PRA). PRA emphasizes local knowledge and involves communities in the inventorying, monitoring, and planning of local forest management [5]. PRA is a good tool for obtaining information for this paper and also for providing information for the community to evaluate its own resource management practices. PRA results from questionnaires, semi-structured interviews, observations, and workshops are analyzed inductively, and suggested measures are given in later paragraphs.

3 Empirical study

3.1 Study area

Chongqing municipality is located in southwest China, with a population around 33 million and a land area of 82,300 km². The mountains of southwest China, where Chongqing lies, provide a wide array of habitats, including the most endemic-rich temperate flora in the world, as well as protected animals like golden monkey, giant panda, etc. However, the destruction of forest is one of the primary threats to the biodiversity in this region. Geographically, Chongqing features “Southwest China Temperate Forest” and “Yangtze River” – two of 200 “Global Ecoregions” identified by World Wildlife Fund (WWF). Chongqing has a forest coverage around 20%. Over 6,000 species of vegetation and over 600 species of animals can be found here. Chongqing is also a major producer of traditional Chinese medicinal plants.

Shizhu TuJia Autonomous County (Shizhu County hereafter) is a county-level division of Chongqing Municipality, and it is located in eastern Chongqing, China (Fig.1). The size of Shizhu County is 3,012.5 km². This case study site Tianwan village is in Huangshui Township; the latter is located in eastern Shizhu, and it covers an area of 157.8 km².

The Dafengbao Nature Reserve which is 200 km² lies in Shizhu County, and is in the list of the IUCN Protected Areas. This case study site is also within this nature reserve.

Shizhu County has around 297 km² of dry agricultural land, of which Coptis planting area amounts to 33 km², with annual output about 1,500 tons. Coptis production in Shizhu County accounts for 60% of China's production and 40% of that of the whole world. However, the traditional way of planting Coptis was associated with the clearfelling of forests to provide Coptis land; it also requires a large volume of timbers for establishing the canopy needed to cover the Coptis plants during its entire 5-year's cultivation time. In the...
meantime, farmers take nutrient-rich forest humus as the main fertilizer for the Coptis. Thus, the Coptis production here has exerted great pressure on natural forests in Shizhu.

Tianwan Village is one of the villages governed by Huangshui Township. The size of its land area is 2.257 km$^2$. A comparison of Tianwan village with Shizhu County on land area, cropland area and Coptis land area is presented in Table 1. Tianwan Village has the same per unit area Coptis output as to Shizhu County's average. Tianwan Village has a much higher dependence on Coptis planting compared to Shizhu County, because the latter has urban part, where many industries and service sectors can be found.

The natural reserves in China have three separate management zones: a core area, a buffer zone, and an experimental zone. Protected areas provide a variety of goods and services for society at large, of which the people living in or near the area should be the primary beneficiary [6]. A recent report indicates that almost all protected areas in China contain human settlement, farming and unsustainable extraction of natural resources [7]. The same applies to my case study area – Tianwan Village, despite the fact that all of Tianwan Village is part of the buffering zone of Dafengbao Natural Reserve, where human settlement is prohibited by law.

### Table 1

<table>
<thead>
<tr>
<th>Place</th>
<th>Land (km$^2$)</th>
<th>Crop land (km$^2$)</th>
<th>Coptis land (km$^2$)</th>
<th>Coptis/crop</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shizhu County</td>
<td>3,012.5</td>
<td>297</td>
<td>33</td>
<td>11%</td>
</tr>
<tr>
<td>Tianwan Village</td>
<td>2.257</td>
<td>0.566</td>
<td>0.29</td>
<td>51%</td>
</tr>
</tbody>
</table>

### Table 2

<table>
<thead>
<tr>
<th>Crop land types</th>
<th>Area size (km$^2$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coptis</td>
<td>0.290</td>
</tr>
<tr>
<td>Water shield</td>
<td>0.070</td>
</tr>
<tr>
<td>Potato</td>
<td>0.066</td>
</tr>
<tr>
<td>Corn</td>
<td>0.040</td>
</tr>
<tr>
<td>Other vegetables</td>
<td>0.100</td>
</tr>
<tr>
<td>Total</td>
<td>0.566</td>
</tr>
</tbody>
</table>

### 3.2 Data collection

#### 3.2.1 Tianwan Village

Tianwan Village has 98 households with 405 villagers. It was classified as part of the Dafengbao Nature Reserve in 1990. Today, although any production was prohibited within the buffer zone by laws, here at Tianwan Village, forest trees continue being cut down to provide new lands and canopies for Coptis planting. The crop land types of this village can be summarized in Table 2.

Tianwan Village is around 1,450 m above sea level with steep farming land. The landscape today is a mosaic of primary and secondary forests, and cultivated land. Among the villagers' production activities, Coptis planting is the most important and oldest one. Per capita annual net income calculated on a self-report basis for year 2008 at Tianwan village was 3,026 yuan.

The reason for choosing Tianwan Village as my case study area is its accessibility. Tianwan Village is located at an exit of G50 Chongqing-Shanghai National Express Way and it serves as the portal to Dafengbao Nature Reserve and Huangshui Township.

A preliminary study was performed in January 2010, which aimed to help developing research questions and better understanding of my research context. Copies of a one-page questionnaire were distributed to 30 households in Tianwan Village and all copies were successfully returned the next day. The questions were Coptis-centered and had a focus on forest conservation and biodiversity. Results show Coptis is the most planted agricultural product in Tianwan Village. Moreover, results from the preference ranking of 10 common local agricultural products highlighted a plant called water shield. This result triggered my interest of further investigation on water shield.

Five semistructured interviews were held with adult farmers. Interview responses were recorded in a notebook, and a tape recorder was used. All of the interviews and discussions were organized in local language: a dialect of Chinese spoken in Chongqing region. Each interview lasted around one hour during a single day. Information related
to household income, land preparation, Coptis planting/management/harvesting practices, and forest conservation was collected.

Results show that Coptis production has long been Tianwan Village's main economic source. Because Coptis is a shade plant, here at Tianwan, villagers follow the historical planting method, which involves cutting evergreen broad-leaved forest trees to provide canopies. In the meantime, villagers take nutrient-rich forest humus as the main fertilizer to Coptis planting.

There are three types of farming lands in Tianwan, namely dry land, water land, and wood land. As for dry land, villagers also plant corn, potato, and other vegetable for their own household consumption besides planting Coptis. Villagers rarely raise pigs or poultry.

As for water land, it was previously used as paddy fields, however, due to Tianwan's high latitude and cool weather; the output of rice is very low. Tempted by the high Coptis price in the past few years, villagers were expanding Coptis planting area. Owing to the negative effects of Coptis planting on forest protection, local government intervened in Coptis land expansion. As a result, some villagers resorted to water shield planting. Water shield is a perennial plant with relatively small, floating oval to elliptical leaves with no slit. And it has a distinctive gelatinous slime on the underside of the leaves and coating the stems. In China, water shield is deemed as a delicious food. Turning from Coptis to water shield improved these villagers' cash income, but its planting mode is also labour-intensive.

As for wood land, all forests in Tianwan are collective-owned and contracted with each household. Although felling is prohibited in nature reserve by law, villagers in Tianwan take it for granted, because they think as long as they replant new trees in their contracted management zone, they will not be punished. In fact, they had never received fines from the government for cutting trees. This is where the biodiversity issues emerge: using fast-growing, mono-type trees to replace primary forest trees leads to a decrease in tree species richness. The vulnerability of mono-type forests will further weaken the biodiversity in forests. Villagers were not aware of the fact that: logging, the human-induced forest change at landscape level here, has led to the loss of natural forest habitats and forest fragmentation, and further caused loss in biodiversity.

Transect walk is a tool for describing and showing the location and distribution of resources, features, the landscape and main land uses along a given transect. When performing a transect walk, it is best to choose a route which will cover the greatest diversity in resources, land use and geographical conditions. The transect walk is conducted by the research team and representatives of the female and male community members.

The transect walk in Tianwan village took place the whole day of February 5, 2010. Four researchers including myself formed a group. During the walk, group members discussed everything encountered and noticed. Ideas were facilitated by asking questions and observation. The team members also informally interviewed any people met during the walk to get their views on land uses and resources at the corresponding spot. Audio record was taken when dialog arose. Problems and opportunities regarding land uses and resources were identified:

1. Coptis fields.

Most of the Coptis fields use timbers as the supporting columns of the canopies made of branches and timbers. Villagers interviewed told us that preparing 1 ha of Coptis field needed around 150 m$^3$ of wood. The 150 m$^3$ of wood requires clear felling of 3 ha forest. One problem with the woody canopy is that severe nature force may sometimes destroy the canopy (e.g. a lasting heavy snow), which need to be replaced with new ones.

Some women encountered working on Coptis field told us that they needed to hire laborers to prepare the canopy and ground soil due to the difficulty of this task. They paid 70 yuan for each laborer's a day work, which amounts to a total cost of 4,000 yuan to prepare 0.1 ha of Coptis field. They complained that Coptis prices were unstable and in 2009 it was very low (40 yuan/kg). 0.1 ha of harvested Coptis produces averagely 300 kg of
product, thus giving an economic return of 12,000 yuan. But after deducting the cost of laborers, fertilizers, the net return was quite small, around 7,000 yuan for 0.1 ha of Coptis over 5 years, considering Coptis’ five years’ cultivation time.

When asked why they went on spending money on framing new canopy instead of switching to other livelihood methods, they said they could not abandon the Coptis which they had planted for 4 or 5 years, and they were glad that Coptis price in the year 2010 went up above 70 yuan/kg. Concerning switching to other livelihood methods, women said they were not adequately educated; besides planting crops, they know nothing about other livelihood methods unless someone trains them.

All Coptis farmers encountered were asked if they had been trained by the local government on improved ways of Coptis planting. All said they had. One woman said that she underwent three trainings hosted by local government. She acknowledged the usefulness of those trainings, and she was expecting for more trainings which will focus on specific local soil properties. By adopting improved Coptis planting and managing methods, she hoped her Coptis quality would improve in the long run to bring her higher cash income, and ultimately elevate her household’s livelihood level.

We also saw Coptis fields along the road using cement as the supporting columns for canopies. Villagers told us these cement columns were provided by the local government for free. By talking with villagers we identified that the trend of cutting trees for making Coptis canopies could not be reversed in the near future, as a large number of Coptis-planting based villages in Shizhu County are still not accessible by vehicles and the inconvenience of transporting these cement columns would involve high costs.

(2) Water shield fields.

Around one third of water land is used as water shield fields. Group members agreed that abundant water resources, and optimal altitude are positive elements for water shield planting. Tianwan is quite ideal for promoting water shield planting. Tianwan is 0.1 ha of water field has the ability to produce 3,000 kg of water shield, with a sale value of 2 yuan per kg. Despite the economic returns, most villagers acknowledged that working in water shield fields causes arthritis and females mentioned the negative effect on their reproductive system. However, they admitted that their cash income greatly increased by switching from Coptis planting to water shield planting, not only because Water shield gives better net return, but also because the buying companies pay them up to 120 yuan subsidy for 0.1 ha of water shield annually.

It takes five years for planting Coptis, while water shield gives continuous annual returns. In simple words, after harvesting, the same Coptis field will not give output for the next four years. Coptis farmers’ strategy is to divide their Coptis land into 5 pieces with each planted with the first year’s to the fifth year’s Coptis respectively to guarantee continuing return from one piece of land. A visualized comparison of net return is presented in Table 3 for 0.5 ha of Coptis and Water shield in year 2009.

The team members agreed that water shield planting could serve as a good alternative to Coptis planting from an economic perspective. There were potential in expanding water shield planting area because of all 24 ha of water field in Tianwan village only 7 ha are now used for water shield planting. However, switching from planting Coptis to planting water shield may shift the ecological burdens from wood land to water land. It is very likely that after years' water shield planting, the water quality will deteriorate (e.g. eutrophication) due to fertilizers input and human laboring.

Villagers told us that frogs, ricefield eels, loaches, etc. could be found in water shield field, and villagers sometimes catch and sell them in market for cash. However, converting natural water land to water shield field may result in loss of natural habitats for the native aquatic birds. Concerning

Table 3

Annual net return from 0.5 ha of Coptis and water shield (Based on year 2009's price)

<table>
<thead>
<tr>
<th>Category</th>
<th>Annual net return (yuan)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coptis</td>
<td>7,000</td>
</tr>
<tr>
<td>Water shield</td>
<td>25,000</td>
</tr>
</tbody>
</table>
the relation between the quality of water shield and forest conservation, a forestry expert in the group commented that, a well-kept forest uphill can filter good quality of water to the submontane water land. There is a newly built reservoir with a volume of 35 million m$^3$ and surface area of 6 km$^2$ to the east of Tianwan Village. In the future, drainages can be built from the reservoir to water shields for the need of high quality water, if necessary.

(3) Villagers’ meeting.

Two villagers’ meetings were held in evenings of February 6th and 7th. Each meeting lasted 4 hours with 40-50 adult villagers. I encouraged the villagers to conduct their own analysis of Tianwan – “What is the status quo of Tianwan Village?” Among the strength, “cool temperature in summer” was discussed most. Chongqing’s summers can be very hot, among the hottest in China. In summer, many Chongqing urban people like to spend weekends in Huangshui Township because the latter has Dafengbao Nature Reserve and Huangshui National Forest Park nearby, and most importantly, because the weather is cool there. Villagers claimed to see much more private vehicles from Chongqing urban area after the opening of G50 Express Way. Tianwan Village is only 5 km away from Huangshui Township. Though it is not a tourist destination, there is a good potential of developing rural homestay here. Among the weakness, villagers identified their lack of access to information and education. Though the younger generation is entitled to full compulsory education, the elder generation can only expect trainings from local government and NGOs to acquire knowledge concerning improved livelihood methods.

Villagers were asked about their general understanding of forest in their village. They thought they had very high forest coverage: trees grow quite fast here, and even fallen trees can often reestablish themselves. I shared with them data showing that forest stock in Tianwan is 5,856 m$^3$ and forest land is 94 ha. This corresponds to 14.5 m$^3$ forest stock and 0.232 ha forest land per capita respectively. Comparing to China’s per capita of 9.048 m$^3$ and 0.128 ha respectively, these numbers which correspond to the village are slightly higher and seem good from villagers’ point of views $^{[11]}$. However, the fact is that China’s forest area per capita is only 20% of the world average and that forest stock per capita is only 12.6% of the world average $^{[11]}$. A summarized comparison of Tianwan Village, China, and world average in per capita forest area/stock is presented in Table 4.

By discussing these numbers, villagers were made clear of the status quo of their forest resources, that the high forest coverage in Tianwan should not be what they are proud of. They should protect the primary forest here, instead of cutting them for Coptis planting.

Then I discussed the following question with them: “How do the current rules and regulations govern resource use?” This question allowed me to identify and resolve potential conflicts between traditional and formal resource management controls in order to develop a more implementable forest management plan $^{[5]}$. At Tianwan Village, systems of resource use and control do not exist. As for Coptis, with villagers we agreed that its planting area should not exceed the current size of 29 ha. A suggested management procedure was summarized as: “Delimit region, limit area, cultivate scientifically, and increase per unit area yield”. Farmers also agreed that diversification toward animal husbandry seemed to be a good rural poverty reduction strategy.

In the end, villagers were asked to suggest a sustainable way for planting Coptis in the future. Some of them mentioned the incorporation of Coptis planting into agroforestry by using local native species to restore mixed woods on Coptis

<table>
<thead>
<tr>
<th>Item</th>
<th>Tianwan Village</th>
<th>China</th>
<th>World</th>
<th>Tianwan to world average (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Per capita forest stock (m$^3$)</td>
<td>14.500</td>
<td>9.048</td>
<td>71.80</td>
<td>20</td>
</tr>
<tr>
<td>Per capita forest area (ha)</td>
<td>0.232</td>
<td>0.128</td>
<td>0.64</td>
<td>36</td>
</tr>
</tbody>
</table>
fields. This is exactly what some researchers are doing, so I shared with them the latest information from a Coptis project by EU-China Biodiversity Programme and Shizhu County Coptis Company. A managed Bamboo Chimonobambusa forest can provide the perfect shady environment needed by Coptis seedlings. This combination can also diversify Coptis farmers' livelihood methods and provide more cash income. Seeding of Chimonobambusa takes place in spring, and their bamboo shoots emerge in autumn. Because of their unique morphological characteristics, delicious taste and nutritional value, these bamboo shoots are quite welcomed on the table. After 2 years' culturing Coptis seedlings, Coptis plants need transplantation. At this time, a sustainable solution is to plant Kiwi trees on Coptis field by using their leaves as natural canopies. Though experiments with many species of trees have been done, considering other issues like the economic outcome or the length of growing time, the Kiwi tree is considered as the optimal choice. Kiwi is a liana, which needs the erection of durable frame immediately after being planted in order to facilitate the growth and results. If the setting of frame erection is not in time, seedlings of Kiwi trees will crawl on the ground instead of growing up straight. This will lead to branches being entangled with each other and further affect the formation of the trunk, which ultimately results in delay of the yield of fruits.

The cement columns being used as substitute to woody columns in some Coptis field are ideal frames for Kiwi saplings. A Kiwi sapling can be planted near a cement column, and one year later the column can be removed. Branches and leaves of mature Kiwi trees can serve as a natural canopy for Coptis, while harvested Kiwi fruit can be sold by farmers in market for cash revenue.

3.2.2 The Coptis market

The Shizhu Coptis Market is located in the center of Huangshui Township. This market opens every Sunday except during Chinese Spring Festival (normally lasts around half month). My on-site study at the Coptis Market took place on February 7th, 2010, in the form of interviewing various stakeholders including Coptis farmers and Coptis traders.

What Coptis farmers care about most is the cash revenue from the selling of harvested Coptis. The amount of cash income from Coptis closely relates to farmers' livelihood standard. However, the market price of Coptis is quite unstable: even in the last decade, can we see large price fluctuations. Table 5 shows Coptis price trend in the last ten years.

Due to Coptis' long planting period, farmers' responses to market demands and price changes are always slow, and this situation is hard to change because most farmers, traders, or even Coptis companies do not have enough financial resources to store the product until the price increases. Additionally, it is impossible for farmers to abandon their fourth year Coptis, even they know that next year's market price will be very low. However, there are still possibilities that farmers can get better income for selling harvested Coptis.

In the market, there is a positive correlation between the drying extent of Coptis and its purchasing price from traders. Traditional household's

<table>
<thead>
<tr>
<th>Year</th>
<th>Price (yuan/kg)</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001-2003</td>
<td>200</td>
<td>Demand increased due to development of medicines using Coptis extracts</td>
</tr>
<tr>
<td>2004-2005</td>
<td>300</td>
<td>Outbreak of SARS in China led to rising price of medicines, and Coptis had a general anti microbial effect</td>
</tr>
<tr>
<td>2006-2007</td>
<td>50</td>
<td>Increased production met normal demand</td>
</tr>
<tr>
<td>2008</td>
<td>50-28</td>
<td>Demand decreased possibly due to global financial crisis</td>
</tr>
<tr>
<td>2009</td>
<td>39-44</td>
<td>Price continuing went up</td>
</tr>
<tr>
<td>2010</td>
<td>70-76</td>
<td>Price in early February, 2010</td>
</tr>
</tbody>
</table>
drying of Coptis can result in a product that is 90% dry. So, if additional drying can be done by farmers, the sale price should increase.

Based on an interview with farmers, those were found: Firstly, the technology and equipment input required by higher drying levels cost a lot. Even that new drying equipments have been devised, which save labor time and fuel wood, they can only slightly improve Coptis' drying level as compared to the traditional equipment. The extra revenue brought by the extra drying will take years to offset the initial investment for such new equipment. When talking with a trader about my above idea, he said it was unlikely that farmers would dry Coptis together by sharing improved drying equipment, because there was competition between individual farmers. The “Business as Usual” scenario for traders in the market involves meeting individual farmers with harvested Coptis in their basket back carrier, and bargaining with the farmer to make a deal on an acceptable price. After one year's labor in the Coptis field, farmers just want to sell their Coptis as soon as possible, instead of storing them. At this time, there emerges a power asymmetry: Firstly, most farmers I talked with did not plan to go back home with their Coptis if they find the market price is too low (walking several kilometers with the harvested Coptis on their back basket). Secondly, none of the traders care if one specific farmer will sell his Coptis to him; while one individual farmer wants to sell his Coptis to any trader if the price is acceptable. Thirdly, traders know well about price information at upper channels of Coptis, while individual farmer does not. A farmer has to passively bargain with an experienced trader – a process the trader calls the “each break” strategy.

One solution to this can be establishing a “Coptis Association” at village level. The Coptis Association will be formed by Coptis farmers with external consultants from township or county level forestry/agricultural offices. The Coptis Association should serve as a platform for sharing sustainable methods in planting, management and processing of Coptis; it should also serve as platform for exchanging market information. While individual farmers should unite and sell their Coptis together to have a greater power to negotiate with traders. An association, an affiliations, or social networks are social capital upon which people draw when coordinated actions are required in pursuing different livelihood strategies [4].

There is a conventional notion rooted in farmers' minds: “more weight, more revenue.” They naturally think if their Coptis is wet, the water inside will naturally add weight to their Coptis and bring more revenue. But they are not aware of, or do not want to accept the fact that, if their Coptis is drier, the purchasing price from traders will be higher. Fig.2 presents a Causal Loop Diagram (CLD) of this relation. CLD is often used in system analysis in order to understand the connection between multi-stakeholders and how their action affects the system. The black loop is an ideal way to improve cash income from selling Coptis, while the red lines (depicted in dashes) are farmers' conceived casual relations. Here farmers miss a linkage that cash income equals that Gross weight of Coptis multiplies unit price, and the decrease of unit price brought by higher water content affects the final revenue more than the increase in gross weight.

The same applies to heavy metal content. Heavy metal content of raw medicinal materials is an indicator which is highly emphasized by medical factories and international buyers. As such, buyers' purchasing price is closely correlated to this factor. A trader who claimed to have the equipment for testing Coptis' heavy metal content claimed that the standard for maximum heavy metal content is 2.0 mg/kg and that most traders purchase Coptis with a heavy metal content of 1.6 mg/kg-2.0 mg/kg. After processings by traders, Coptis is resold with a heavy metal content of 0.7 mg/kg-0.8 mg/kg.

According to Coptis traders interviewed, heavy metals in Coptis mainly come from the use of chemical fertilizers. This places farmers in a huge dilemma: low heavy metal content means less chemical fertilizer input, which leads to less output. Given that farmers need cash to buy fertilizers for next year's cultivation, they would rather choose to bear the slashed price quoted by buyers,
instead of finding a way to reduce the heavy metal content. Fig. 3 presents a CLD of this relation.

Input of chemical fertilizer actually results in a balanced loop; however, red lines (depicted in dashes) show farmers’ conceived causal relation between input of chemical fertilizer and their cash income. Just as the case above, the decrease in unit price due to higher heavy metal content, affects the final revenue more than the increase in annual Coptis output.

A possible solution is to adopt an organic Coptis planting mode, in which the selection of fertilizer is the key. A recent study performed by local Coptis technicians focuses on the dedicated Coptis fertilizer which is based upon the nutritional requirements of Coptis at different growth stages. The ultimate aim is to improve the yield and quality of Coptis.

4 Results and discussions

4.1 Problems with the establishment of natural reserves

A very special case of changes in land applications is the establishment of nature reserves. Important criteria for the state to establish nature reserves include high biodiversity, species richness, unique ecosystems, and high endemism \[6\]. The establishment of natural reserves has also been widely associated with loss of legal access to productive resources, such as swidden land, pasture, construction timber \[12\]. However, like most cases in China, the establishment of rural communities (Tianwan Village in my case) came much earlier than the establishment of nature reserves. Most of world’s poor living in rural areas has to depend directly on biodiversity for their well-being and survival \[13\]. At community level, the population growth, together with other specific drivers, such as transformation of land for food production and procurement of construction timber, has exerted great pressures on the environment \[12\]. Furthermore, the three management zones of a nature reserve have different roles. However, different zones are rarely marked in the field and often ignored in practice \[7\]. Lastly, migration is not an ultimate solution to this dilemma. The Chinese government has to find a way to coordinate the relation between nature reserves and local people.

4.2 Sustainable forest management

A report from The World Bank indicates that China’s natural forests have been in a state of continuous decline for 50 years, and there are no signs
that sustainable management of natural forests has even started\cite{14}. The devastating floods in the middle reaches of the Yangtze River during the summer of 1998, were caused at least in part by deforestation in the catchments of the river. Soil erosion induced by deforestation in the catchment areas resulted to a large amount of sediment deposited in the reservoirs, whose capacity is largely reduced\cite{15-17}. Shizhu County is in the upper-middle catchment areas of Yangtze River, and it is also in the reservoir area of the Three Gorges. There is only a less than 20 km linear distance from Tianwan Village to the Yangtze River.

Immediately after the flood in 1998, the State Council took a number of decisive actions: a ban on logging in natural forests, a prohibition on opening of new lands at the expense of forests, etc. But these bans have not proved to be effective enough mainly for lack of enforcement in remote rural areas like here at Tianwan Village. In 2003, the State Council implemented another policy called “Grain for Green”. The core of this policy is that farmers can convert their sloping farmland into woodland on a voluntary basis. The State will provide farmers with grain and cash subsidies for livelihoods, and subsidies for seeds and seedlings needed in the afforestation. A participatory socio-economic survey by Ye et al shows that the basic living standards of farmers can be guaranteed by government subsidies\cite{18}. Though there were concerns about this policy’s effect on grain supply, studies show that its impact on grain support at national level was very small (2%-3%), and it had almost no impact on grain prices\cite{18,20}. At Tianwan Village, although most of the Coptis fields are on flat land due to the difficulty of establishing canopies on sloping land, I can still see Coptis field on sloping land during the transect walk. This policy actually quite fits Tianwan Village. Firstly, farmers here do not have to worry about the impact on local grain supply or price because they do not grow grain here. Secondly, fruit trees or bamboo forest planting can be adopted, which give farmers dual sources of benefits from both the state and the harvest. Actually, some farmers I met in the transect walk had already fully converted their Coptis fields on sloping land into young forest. Concerning farmers’ 5-year Coptis planting strategy, the fastest farmers who responded to this new policy had just finished converting their Coptis land.

Forests in China are either state-owned or collective-owned. The latter means the forest resource is owned by local communities. By data analysis, the World Bank found that the collectives had managed their resources much better than the state-owned sector; and as for the latter, the factors contributing to poor management of state-owned forests are similar to many other sectors in the centrally planned economy\cite{14}. The factors can be summarized as: a focus on production at the expense of forests destruction, the financial burden to meet social needs of employees, lack of incentives and sometimes perverse incentives for management staff\cite{14}.

All forests in Tianwan Village are collective-owned. Like most cases in China, the collective forests are de-collectivized in the form of rural the Household Responsibility System (HRS). The HRS is an agriculture production system, which allows households to contract land and other facilities from collective organizations. All collective-owned forests in Tianwan Village are contracted to each household. If villagers cut trees, they have to replant new trees immediately. The mono-type fast growing trees villagers usually replanted, can result in the loss of forest biodiversity, not to mention the fact that younger forests are worse at retaining soil and water comparing to primary forests. It is suggest that forestry staffs should give trainings to farmers concerning the choosing of tree species for the reforestation activity.

Chhatre and Agrawal’s study shows that when local users perceive insecurity in their tenure because the forest lands are owned by the central government, they extract high levels of livelihood benefits from forests, and when they have safe tenure, they conserve the biomass in such forests. They further suggests that payments from the government to local people, for improved carbon storage in the forest, can contribute to climate change mitigation without adversely affecting the local people's livelihood\cite{21}.
All land in China is owned by the state. Thus, a challenge in the future is if the state can provide secured tenure of the HRS forest, so that their custodians will make the long-term investments necessary to sustain the forest resource [14].

4.3 Participatory methods

Xu et al claim that local people are rarely included in planning, monitoring, evaluation, or management decisions [6]. However, they did not show why local people are excluded from such activities; or it is simply because that the exclusion is the “Business as Usual” scenario in China’s rural areas. Based on my own PRA research in Tianwan village, I think this more or less related to insufficient trainings of farmers on these activities, caused by the spatial distance and the low education level of farmers. In China's hierarchical governmental administration, township government is the lowest; and only the county government and the above have dedicated agencies for forestry, agriculture, labour and social security. In short, the agencies making such planning do not exist at the village level. However, I think in the future, more rural participation should be included in forestry policy makings. Shi and Xu’s work shows, in areas where there is adequate participation of farmers in planning, less deforestation has occurred [22].

The data and information collected in Tianwan Village through the PRA tool are quite useful for my later analysis. Together with secondary data derived from official channels, literature studies, and my own observations, a triangulation of data source is really achieved. I, as an outsider served as convener and catalyst, facilitated local people's active analysis and planning of their own livelihoods, made them participate in achieving sustainable livelihoods in the future.

4.4 Sustainable livelihoods

Concerning sustainable livelihoods, there are many existing approaches and frameworks. According to Institute of Development Studies (IDS) framework for investigating sustainable rural livelihoods [4], a tentative sustainable livelihoods pathway for Tianwan Village would be:

(1) A particular context (policy settings, geographic settings, socio-economic conditions).

(2) A combination of following livelihood resources: a. Natural capital: the natural resource stocks (soil, water, forest, genetic resources, etc.) and environmental services (reservoir, etc.). b. Economic or financial capital: the capital base (villagers' own savings, external poverty alleviation funds, improved equipments and methods for planting, etc.). c. Human capital: knowledge brought by outsiders, trainings brought by the government. d. Social capital: transportation networks, market networks of each agricultural product, the Coptis Association, social relations with NGOs, etc.

(3) A combination of the three livelihood strategies: a. Diversify to a range of non-Coptis-planting income earning activities: for example, water shield, fruit trees, and bamboo planting, or under-forest poultry domestication. b. Agricultural intensification/extensification: as for Coptis, more output per unit area by planting methods improvement is welcomed, but extension of planting area is not suggested. c. Migration: Tianwan villagers may move away and seek a better livelihood in cities if policies allowed. This is also a solution to the dilemma of nature reserves.

5 Conclusion

The contradictions between forest conservation and Coptis planting have been shown here. From this case study, I found that although villagers do have some knowledge about the importance of protecting the forest, they still cut a large amount of trees for Coptis planting, and even with intensive cultivation of Coptis, they still live in poverty. The root of this problem lies in the lack of livelihood methods: people in Tianwan Village have historically followed a Coptis-centered livelihood approach. A solution to this problem is to diversify to a range of non-Coptis-planting income earning activities. This research shows that water shield is an ideal substitute to Coptis, from both environmental and economical perspectives. As for Coptis,
bamboo and fruit trees can be incorporated into its cultivation, which not only diversifies villagers' income sources and reduces the economic risk brought by unstable Coptis price, but also recovers the forest at the same time. Furthermore, improvements in Coptis fertilizers, processing technologies and equipments, together with better strategies for farmers in marketing their Coptis products, are also important for villagers to get better revenue from the Coptis planting.

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