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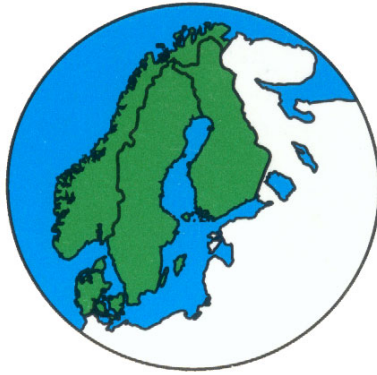
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Trade chain analysis of *Ophiocordyceps sinensis* and *Tricholoma matsutake* in Bhutan

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Abstract

Expanding markets of non-timber forest products (NTFPs) and increasing interest in traditional medicines and health foods have resulted in a growing trade of these NTFPs at local, national and international levels. The trade provides income-generating opportunities for rural people in developing countries but may also jeopardize sustainable harvest levels. The objective of this study was to investigate the trade chains and contribution to rural households of two commercially important NTFPs in Bhutan; the insect-pathogenic fungus *Ophiocordyceps sinensis* and the mycorrhizal mushroom *Tricholoma matsutake*. Access mapping and commodity chain analysis was used as analytical framework. Information on household incomes, quantities, time spent, prices, and expenses were obtained through semi-structured interviews with collectors, middlemen and traders including exporters. Net income was calculated for all actors. Distribution of incomes between actors was calculated. Collectors of *O. sinensis* obtained a higher net income per kg than middlemen and traders while the opposite was the case for *T. matsutake*. Collectors of *O. sinensis* earned an average of 70% of the household's cash income from collection and sale of the product while *T. matsutake* on average constituted 9% of collectors' household income. Based on the study, opportunities for increasing NTFP collectors' net income are discussed. Over-exploitation and habitat destruction was a common concern among collectors of *O. sinensis* and *T. matsutake*. Further research on the biology of the species, the resource base and the impact of increasing collection and trade is needed to ensure sustainable harvest levels.

Keywords: Access mapping, gender, household income, market survey, NTFP, socio-economics.

1. Introduction

Traditional medicine and health foods are used in a variety of goods from raw materials to processed and packaged products like pharmaceuticals, herbal medicines, tea, spirits, cosmetics, sweets, and dietary supplements (Lange, 2006). Around 70,000 plants species are used in indigenous and traditional medicine and health-care systems worldwide (IUCN, 2007). It is estimated that 80% of people in developing countries depend on traditional medicine (WHO, 2010). Globalisation, expanding markets for non- timber forest products (NTFPs) and increasing interest in traditional medicines and health foods have resulted in a growing trade of these NTFPs in both developing and developed countries. The demand for NTFPs for domestic and commercial purposes results in a considerable trade on local, national and international markets (Lange, 2006). The annual world market for plant-based medicine is estimated at USD 20-40 billion with an annual growth rate of 10-20 % (Larsen and Olsen, 2007). The trade provides income-generating opportunities for rural people in developing countries but may also jeopardize sustainable harvest levels (Godoy et al. 1995).

The marketing of NTFPs is normally carried out in two main stages; i.e. the marketing of the raw material from the stage of gathering it until it reaches the industrial user, and the marketing of the semi-finished or finished industrial or finished consumer product either to other processing industries or to final consumers (Lintu, 1995). Though in many cases, the products collected have very high value as final products, the collectors generally receive only a small share of the final value either because they are not aware of the real value or unable to market it to the buyers where they can get reasonable prices for their products (Neumann and Hirsch, 2000). Other reasons associated with low price for collectors may be lack of market information, inaccessibility of the markets, and inability to sell the products in the form or quality desired by buyers. NTFPs are often collected either by wage laborers or farmers with small land holdings and a significant part of the material is commercially traded. The prices paid to the collectors tend to be very low, partly because of ready availability of cheap labor to undertake the very labor intensive work of gathering (FAO, 2005). The contractors who employ the collectors often act as middlemen and traders as well, and collectors usually are dependent on the contractors as they are poor and frequently owe money to the contractors (Neumann and Hirsch, 2000). Further, the supply chain is often very long with as many as six or seven marketing stages involving primary collectors and producers, local contractors, regional wholesale markets, large wholesale

markets and specialized suppliers. This results in primary collectors and farmers receiving low prices for their products (Veeman, 2002).

Commodity chain analysis is a tool for analyzing how markets operate and who benefits, how they benefit, and how those patterns of benefit distribution might be changed. In commodity chain analysis the focus remains on the sequence of processes which extends from the extraction or harvesting of the primary commodities, through the intermediate processing stages, to the production of the finished products and their sales to consumers (Talbot, 2002). It analyses the nature of the commodity flows to and from each stage, and the geographic distribution of the flows. By focusing on the whole range of activities and relations associated with production, exchange, transport and distribution of a particular commodity, the commodity chain approach is simultaneously a descriptive tool and an analytic instrument (Jensen, 2008).

Access mapping leads to evaluation of the distribution of benefits along the commodity chain and draws out the mechanisms responsible for access to benefits (Ribot, 1998; Ribot and Peluso 2003). Access mapping includes; i) identifying the actors involved in the extraction, production, processing, exchange, transport, distribution, final sale and end use of the commodity. More specifically it includes i) identifying the actors along the commodity chain; ii) evaluating income and profit at each level of (or among groups of actors within) the commodity chain through the analysis of prices and quantities of the goods handled by the different actors; iii) evaluating the distribution of income and profit within each group along the chain; and iv) using the distribution of these benefits among and within groups to trace, or map, the mechanisms by which access to benefits is maintained and controlled Ribot (1998).

We used access mapping to investigate the trade chains and contribution to rural households of two commercially important NTFPs in Bhutan; the insect-pathogenic fungus *Ophiocordyceps sinensis* and the mycorrhizal mushroom *Tricholoma matsutake*.

2. Study area

Bhutan is known as 'Menjong Gyelkhap' meaning the land of medicinal plants. It is located in southern Asia between India and China and covers an area of approximately 47,000 sq. km (Fig. 1). The country spans elevations from about 100 to 7500 m above sea level. The climate varies greatly from tropical in the southern plains, cool winter and hot summers in central valleys and extreme winters and cool summers in the Himalayas. The terrain is mostly mountainous with some fertile valleys and savanna. About 70% of the country is forested with numerous deciduous and evergreen species ranging from tropical

hardwoods to predominantly oak and pine forests. The population of Bhutan is close to 700,000. The majority of the population is engaged in agriculture and it is estimated that about 70% of the households depend on forest resources for food, firewood and traditional medicine (Wangda and Ohsawa, 2006). Per capita GDP was 5,600 USD in 2008 (CIA, 2009). Survey sites for *O. sinensis* collection were within the Choekor block and survey sites for *T. matsutake* collection were in the Ura block both within Bhumtang District (Fig. 1). Market surveys were conducted in Thimphu, the capital of Bhutan, and in Paro, a historic city. Most NTFPs are exported from these two cities.



Figure 1. Bhutan (upper left insert) and its districts. Survey sites for *O. sinensis* collection were within the Choekor block and survey sites for *T. matsutake* collection were in the Ura block both within Bhumtang District (upper right insert, from). Market surveys were conducted in Thimphu, the capital of Bhutan, and in Paro, a historic city. Most NTFPs are exported from these two cities. Source of maps: CIA 2009, www.bhutan.gov.bt/government/dzongkhags.php, www.bumthang.gov.bt/map.php

3. Methods

Quantitative and qualitative data were collected through semi-structured interviews following pre-printed questionnaires. The questionnaires were pre-tested and modified to match with the field situations and to rectify ambiguities. Interviews were conducted in villages, at road-heads and in cities with assistance from a translator. The snowball method was used to identify respondents. Identification of collectors was done through key informants such as village heads, and through local forest department's records of permit holders. Middlemen and traders were identified on the basis of information gathered from collectors. Exporters were identified by traders.

For *O. sinensis* thirty-nine collectors from seven villages of the Choekhor block, one middleman in Bumthang and eight *O. sinensis* exporters in Thimphu were interviewed. For *T. matsutake*, twenty-one collectors from five villages of Ura block, four medium-level traders including one middleman in Paro, two retailers at Ura road-head, one head of a user group in Ura and four exporters in Thimphu and Paro were interviewed.

In the commodity chain analysis, the annual amount of *O. sinensis* and *T. matsutake* collected and sold, selling prices and the costs associated with collection were recorded for individual collectors. As a basis for analyzing individual household's cash income, all sources of cash income to households were considered in the interviews. For the economic valuation of *O. sinensis* and *T. matsutake* collection, quantities collected in a day, time spent, and distance covered to reach collection sites were recorded. For middlemen and traders the quantities purchased and sold, buying and selling prices, and overhead costs per kilogram were recorded. Dry weight was used for *O. sinensis* and fresh weight for *T. matsutake*.

Income, cost and net margins were calculated for all actors in the commodity chains for *O. sinensis* and *T. matsutake*. Furthermore, the relative household cash income from *O. sinensis* and *T. matsutake* was calculated. Daily income from collection of *O. sinensis* and *T. matsutake* were calculated and compared with daily wage rate. Finally, the distribution of incomes in the market for *O. sinensis* and *T. matsutake* was calculated.

Data on processing, perceptions about the resource base and specific problems associated with the trade were also included in the interview. Interviews were conducted between February and April 2009 and focused on collection activity in year of 2008.

4. The species investigated

Ophiocordyceps sinensis, commonly known as Cordyceps, Yartsa goenbub or Bub in Bhutan, is a fungus that parasitizes moth larvae (Figure 2). The fungal spores infect the live caterpillar in late summer and the mycelia take over its body after it has buried itself for winter hibernation (Gould, 2007). *O. sinensis* is harvested over much of the Himalayan plateau as a highly prized remedy in traditional Oriental medicine. *O. sinensis* is gathered in high altitude and rugged mountains by rural collectors in Bhutan to supplement their households' cash income. Over the past 10 years its financial value has increased dramatically, with collectors paid as much as USD 12,500 kg⁻¹ for top-quality material. This is causing concern that the present rate of collection is unsustainable. Since 2004, the Royal Bhutanese government has issued permits to collect the fungus during one month within May to June and licenses for traders to sell in one of the government auctions held each summer.

Tricholoma matsutake commonly known as matsutake or pine mushroom, is a highly sought after mycorrhizal mushroom that grows in Asia, Europe, and North America. It is prized by Japanese for its distinct spicy-aromatic odor. It is known in Bhutan as Sangay Shamu (Figure 3). *T. matsutake* grows under trees and are usually concealed under fallen leaves on the forest floor. It forms a symbiotic relationship with the roots of a limited number of tree species. In Bhutan, the mushroom grows mostly in pine forests of Thimphu and Bumthang districts over 3000 m.a.s.l. Domestic production of matsutake in Japan has been sharply reduced over the last 50 years due to a pine nematode *Bursaphelenchus xylophilus*, which has led to increased prices. The price for matsutake in the Japanese market is highly dependent on quality, availability, and origin. The average value for imported matsutake is about USD 90 per kilogram. Bhutanese villagers collect it and sell to supplement their households' cash income. Collection is allowed for four months from July to October.



Figures 2 and 3. Dried *O. sinensis* and fresh *T. matsutake*. Photos V.K. Shrivastava and <http://en.academic.ru/pictures/enwiki/77/Matsutake.jpg>.

5. Results

5.1 *O. sinensis*

Most collectors of *O. sinensis* were small farmers. Both men (77%) and women (23%) take part in collection of *O. sinensis*. The illiteracy rate was high among collectors (77%) while 18% had finished primary school. On average collectors walked three days to reach the camp from where they undertake daily collection trips. On average, collectors spent two months collecting with men collecting over a longer period than women. The quantity collected per day varied from 2.6 g (13 pieces) to 13 g (71 pieces). Men collected somewhat more per day than women. The total average amount collected per person in 2008 was 400 g. Collectors sold at an average price of 2411 USD/kg and almost all of the harvest was sold. Collectors had very few costs, the main expenses being a permit of USD 0.3, tents and kerosene. Collectors' net income/kg was USD 2267 equivalent to a daily net income of about USD 18 or 9 times more than the official minimum daily wage in Bhutan. Results are shown in Table 1. There was no correlation between amount sold and selling price. According to collectors quality determine the selling price rather than amounts traded.

Table 1. Collection and income for *O. sinensis*.

	All households (n=39)		Women n=9		Men n=30	
	n	Mea error	n	Mea error	n	Mea error
Household members involved	1.46 2	0.08 9	1.55 6	0.17 6	1.43 3	0.10 4
Days to base camp (~80 km)	2.77	0.11	2.78	0.15	2.77	0.14
No. of collection days	66.7	9.2	54.5	14.6	70.3	11.1
Quantity collected (kg)	0.41 9	0.04 7	0.25 3	0.05 3	0.46 9	0.05 6
Quantity sold (kg)	0.41 4	0.04 7	0.24 2	0.04 9	0.46 6	0.05 6
Average collected per day (kg)	0.00 80	0.00 08	0.00 60	0.00 13	0.00 86	0.00 10
Price (USD/kg)	2411	100	2511	163	2381	122
Gross income calculated (USD)	998	128	577	99	1125	158
Net income calculated (USD)	956	128	554	98	1076	158
Net income (USD/kg)	2267	111	2375	165	2235	137
Mean daily net income (USD)	18.3 4	2.16	14.5 6	3.13	19.4 7	2.63
Net income/min daily wage	9.2	1.1	7.3	1.6	9.8	1.3

Villagers largely depended on agriculture and livestock for their livelihoods. Some villagers worked as daily wage labourers. *O. sinensis* was found to provide a major contribution to households' annual cash income. Thus, income from *O. sinensis* constituted about 70% of the individual households' income and it was the only source of cash income for 26% of the households (Fig. 4). There was no significant correlation between income from *O. sinensis* and households' assets or incomes from other sources.

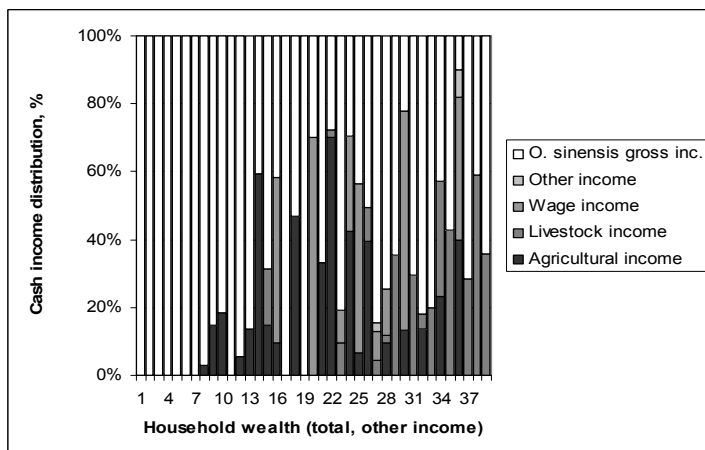


Figure 4. Distribution of cash income. Households are ordered according to increasing household wealth.

Most *O. sinensis* collectors sell directly to exporters. According to 97% of the collectors the presence of middlemen was very limited. Collectors did not negotiate prices as these were decided in advance by the traders who participated in the government auctions. The few collectors who had tried to negotiate for better prices did not succeed. The trade chain for *O. sinensis* is shown in Figure 5. Collectors experienced by far the highest net income per kg and middlemen the lowest. However, when factoring in the amounts traded the yearly mean net income from *O. sinensis* was USD 956 for collectors and USD 52,600 for exporters.

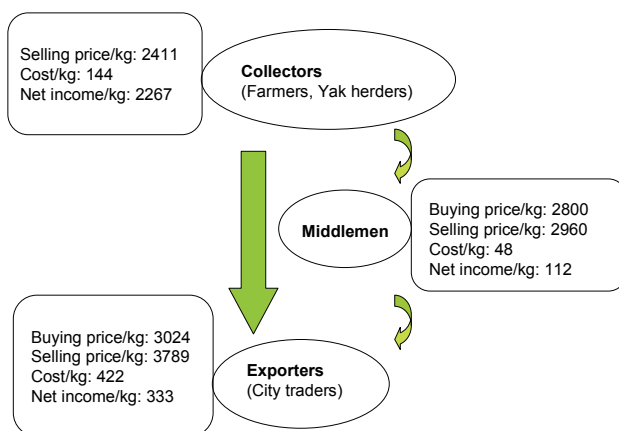


Figure 5. Trade chain for *O. sinensis*. Figures are in USD. Collectors have the highest net income per kg and middlemen the lowest. Most collectors sell directly to exporters. Rarely middlemen are involved in the trade.

5.2 *T. matsutake*

Collectors of *T. matsutake* interviewed were all farmers except for one who was a monk. Women comprised the majority of collectors (57%). Most collectors were illiterate (86%) while 9% had finished primary school. *T. matsutake* was collected almost exclusively for sale while small quantities were consumed within the households. Other mushrooms such as *Lyophyllum shimeji* were also collected for sale while others were collected mainly for domestic consumption. Only *T. matsutake* is included in the data presented here.

The average quantity collected per day varied from 1.2 to 1.8 kg. Men collected somewhat more per day than women and spent more time collecting. The average quantity collected per person within the season of 2008 was 28 kg. For women and men the mean quantities were 19 kg and 40 kg, respectively. Collectors sold at an average price of USD 3.97 per kg and 83% of the harvest was sold. Collectors had very few costs and their net income per kg was USD

91 equivalent to a daily net income of USD 5.25 or 2.6 times more than the minimum official daily wage in Bhutan. Results are shown in Table 2.

Table 2. Collection and income from *T. matsutake* collection.

	All households (n=21)			Women (n=12)		Men (n=9)			
Variable	n	Mea	Std. error	n	Mea	Std. error	n	Mea	Std. error
Household members involved		1.24	0.10		1.33	0.14		1.11	0.11
Distance to collection site (km)		5.43	0.67		5.33	0.80		5.56	1.21
Time collecting (hours)		1.43	0.17		1.39	0.22		1.48	0.27
Number of man days collecting	1	23.3			19.1			28.8	
		28.1	4.18	9	19.1	5.16	1	40.1	6.81
Quantity collected (kg)	7		5.15	7		3.97	7		9.72
Quantity consumed (kg)		4.71	1.14		2.83	1.17		7.22	1.91
		23.4			16.3			32.9	
Quantity sold (kg)	5		4.82	3		3.62	4		9.57
Mean quantity per day		1.35	0.13		1.19	0.14		1.56	0.21
Selling price/kg		3.97	0.05		3.92	0.08		4.04	0.04
		91.7	18.7		61.1	11.1		132.	38.1
Gross income (USD)	1		3	7		6	44		4
		91.3	18.7		60.7	11.1		132.	38.1
Net income (USD)	1		3	7		6	04		4
Net income (USD/kg)		3.94	0.05		3.88	0.08		4.02	0.04
Mean daily net income (USD)		5.25	0.46		4.51	0.41		6.24	0.83
Net income/min daily wage		2.64	0.23		2.27	0.21		3.14	0.42

T. matsutake collectors mainly depended on agriculture and livestock for their livelihoods while income from daily wage labour comprised a major component for a few households. *T. matsutake* was found to contribute up to 40% of the individual households' income with an average of 9% (Fig. 6). There was no significant correlation between income from *T. matsutake* and households' assets or incomes from other sources.

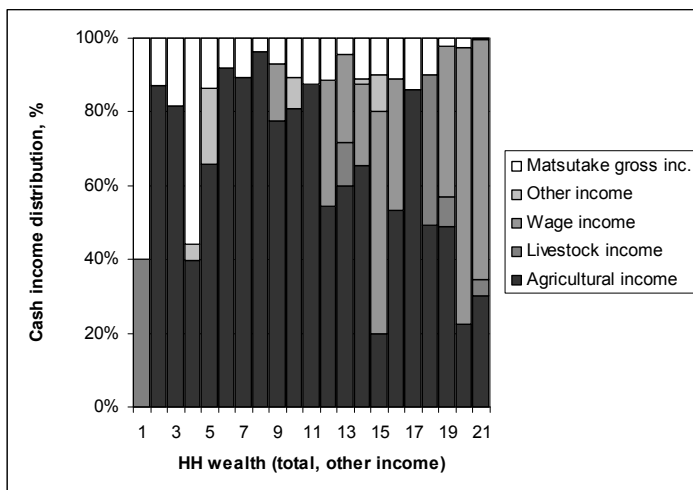


Figure 6. Distribution of cash income. Households are ordered according to increasing household wealth.

About 50 % of the collectors sold their harvest in the local market, usually a road-head market, to agents of exporters who were present at the markets during the *T. matsutake* season. Collectors also sold to travelers, mainly Japanese tourists, who usually buy matsutake during their visits to the Districts. Almost 40% of the collectors were members of *T. matsutake* user groups. They sold to their respective group from where it was resold to exporters. The rest of the collectors either sold in sub-local markets directly to consumers, to other collectors like the village head, or they sold to FCB shops (Food Corporation of Bhutan) from where they could exchange matsutake mushrooms for other household commodities. The majority of collectors (62%) did not know about the involvement of middlemen in the trade. Most collectors (76%) did not negotiate prices and not a single collector had succeeded in getting a higher price through negotiation. This may be due to the fact that there were only few traders in the market and the fact that collectors had to sell the fresh mushrooms the same day as they had no proper storage facilities. Collectors believed that better storage facilities, drying equipment, more buyers, user groups, and

government auctions could help them to get a better price. According to the collectors, some of the factors that affected the price were quality, number of buyers and increased competition between them, and the numbers of Japanese tourists. Two-thirds of the collectors had no information about other matsutake markets in the country while one-third had heard about other markets and had the perception that prices were higher in other markets than the one where they sold their harvest.

The trade chain for *T. matsutake* is shown in Figure 7. Traders experienced the highest net income per kg and user groups and retailers the lowest. Though selling prices per kg for exporters are ten times that of collectors, costs are also high (refrigeration and air freight). When factoring in the amounts traded the yearly mean net income from *T. matsutake* was USD 91.3 for collectors and USD 44,262 for exporters.

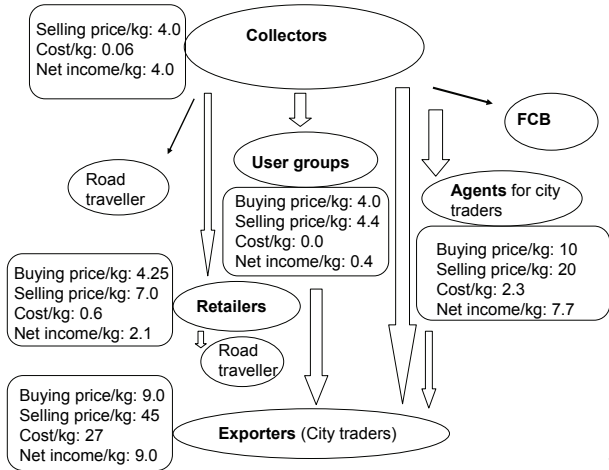


Figure 7. Trade chain for *T. matsutake*. Figures are in USD. Traders experience the highest net income per kg while user groups and retailers has the lowest. Most collectors sell directly to exporters or agents for city traders. A considerable quantity is sold to user groups, and less to FCB (Food Cooperation Bhutan) and travellers (tourists). Exporters selling price is ten times that of collectors but exporters' costs for refrigeration and air freight are also high.

5.3 Distribution of incomes in the market for *O. sinensis* and *T. matsutake*

Finally, we calculated the distribution of net income for the two NTFPs based on the quantities of the two products represented by the survey, prices and the number of collectors and traders represented. The distribution of incomes in the market was markedly different for the two products. For *O. sinensis* 75% of the net income in the market was distributed between collectors. The opposite was the case for *T. matsutake* where only 20% of the total net income was distributed between collectors. At the household level, *O. sinensis* collectors had a net income corresponding to 0.02% of traders' net income while collectors of *T. matsutake* made 0.004% of traders' net income (Table 3).

Table 3. Distribution of incomes in the market for *O. sinensis* and *T. matsutake*. Incomes of collectors are scaled to match the observed amounts traded.

	Net incomes (USD) corresponding to observed trade	
	<i>O. sinensis</i>	<i>T. matsutake</i>
Collectors	1,510,449	51,636
Traders	487,862	215,861
Collectors/trade	3.10	0.24
	Average net income (USD) per household	
	<i>O. sinensis</i>	<i>T. matsutake</i>
Collectors	1,089	105
Traders	54,207	26,983
Collectors/traders	0.020	0.004

5.4 Sustainability of the trade

Collectors of *O. sinensis* and *T. matsutake* had contrasting perceptions of the status of the resource base (40% believed *O. sinensis* had become scarcer in the past 5 years and 40% believed there was no change). Collectors of both products shared a common view (70%) that the harvest was gradually becoming unsustainable due to overexploitation and habitat destruction as increased prices lead to increased extraction. This perception was supported by many city traders. Especially *T. matsutake* traders claimed that smaller amounts of poorer quality were traded today as compared to 5 years ago.

6. Discussion

Traditional medicine is used by billions of people in developing countries, because of their low costs, their effectiveness, the frequently inadequate provision of modern medicine, and cultural and religious preferences (Sheldon et al., 1997; Shanley and Luz, 2003).

The trade in traditional medicine not only provides vital welfare for millions of consumers but it is also critical for the welfare of all the people engaged in the industry. The annual global market for herbal remedies, estimated at approximately USD 23 billion (Crabb, 2004), makes a considerable contribution to the economies of producer countries (Schippmann et al., 2002). For example, in Tibet the income from sale of *O. sinensis* often accounts for 70-90% of a family's annual cash income in areas where it grows (Winkler, 2008). Many studies have shown poorer households to be more dependent on harvest of NTFPs than wealthier ones (Cavendish 2000; Vedeld et al. 2007) while other studies have found elite capture prevalent for very valuable NTFPs (Neumann and Hirsh, 2000; Dove 1993). In this study, 23% of the *O. sinensis* collectors were women and 77% were illiterate while 75% of the *T. matsutake* collectors were women, and 86% of the collectors were illiterate. However, there was no significant correlation between household incomes and incomes from collection of the two products. Yet, both products have a potential to provide an income to women and uneducated people.

A range of studies have described NTFP trade chains from various countries, i.e. for charcoal in Senegal (Ribot 1998), agarwood in Laos (Jensen 2009), medicinal and aromatic plants in Nepal (Olsen 1998), medicinal plants in South Africa (Botha et al 2004), and in Benin (Vodouhe et al. 2008). The structure of the markets can be highly complex and the relationship between actors dynamic and often in the form of patron-client relationships (Neumann and Hirsh, 2000). A common assumption is that the relationship between collectors and traders is exploitative and that large margins remain with the middlemen and city traders. Edwards (1996) suggested that removing some levels of intermediaries from the chain can increase the margin share of collectors. On the contrary some studies cited by Neumann and Hirsch (2000) suggest that middlemen have important functions in the trade chains and do not always have an exploitative role. The commodity chain of *O. sinensis* within Bhutan is relatively short (only one level of intermediaries) and can be broadly divided into three levels, namely collectors, middlemen and city traders/exporters. The trade chain of *T. matsutake* is more complex. Though most collectors sell directly to city traders or agents of city traders, several

other options exist, i.e. sale to local retailers, user groups, tourists, or government corporations.

The distribution of incomes in the market was markedly different for the two products. Collectors of *O. sinensis* gain a significantly higher percentage of incomes than *T. matsutake* collectors. There are more actors and levels in the *T. matsutake* trade chain. However, the presence of agents and local retailers does not seem to be exploitative as little margin remains with these groups. On the other hand, the presence of numerous different buyers did not seem to provide collectors a better price through increased competition among buyers as compared to *O. sinensis*. Another question is why the user groups are unsuccessful in bargaining for higher prices. One of the answers may be that selling larger quantities does not necessarily lead to better prices per kg. This is in accordance with a study from South Africa (Williams et al., 2007) showing an inverse relationship between price per kilogram and quantities sold. User groups may also have low bargaining powers due to lack of information about price structure in the market, poor networks to city traders and exporters or inefficiency.

The total net income for traders and exporters of the two products are very high compared with those of collectors and middlemen and their returns of investment may be very high compared to the short term of the investment. However, international trade in NTFPs has a trend of boom and bust and is subjected to price fluctuation, higher quality standards, sophisticated market preferences and international trade rules (Neumann and Hirsch, 2000). This is also the case for *O. sinensis* (Cannon et al, 2009). Hence, traders need a huge capital to enter the market and are prone to risks. This together with the government-controlled licensing of exporters and government-controlled auctions may facilitate small elite of traders to monopolize the trade. In 2008, there were 55 registered traders of whom only 27 turned up at the auctions held at 10 locations in Bhutan between July and August 2008 (MoA, 2008). The trade in *T. matsutake* is not controlled to the same extent as *O. sinensis*. Traders do not need a license but the quality of drying, grading and packaging is inspected by Bhutan Agriculture and Food Regulatory Body before export. All *T. matsutake* traders lived in a city, most had completed further education, and mushroom trade was a side business for all of them. Four of the city traders in this study were said to control 90% *T. matsutake* trade in the region and 75% of the export from Bhutan. Thus, the export of both NTFPs seemed to be controlled by relatively few individuals.

Usually the market values of individual NTFPs vary considerably and price structures fluctuate between markets and over time as the cost of harvesting a

species depend on gatherer's access to the resources and proximity of markets to the harvesting sites. In the case of *O. sinensis* and *T. matsutake* prices do not seem to be determined by collectors' effort. Rather it is decided by a restricted number of traders and international markets. Collectors of both *O. sinensis* and *T. matsutake* pointed to improved quality (size, cleaning and drying) as the best way to increase their income. Many also suggested that more traders should participate in the auctions, auctions to be held in more places to improve access of local traders, lifting of government control with the markets, and government intervention to prevent manipulation of prices by traders. A few collectors felt that transparency in price structures and information about prices would allow them to increase their selling price. Though most collectors did not wish for more government intervention in the NTFP trade, they did in many cases expect the government to facilitate infrastructure and a price structure to increase the incomes of NTFP harvesters. While most *O. sinensis* collectors were in favour of less government control of the trade itself, some *T. matsutake* collectors suggested government controlled auctions as practiced for *O. sinensis* in order to secure collectors a better price. Some collectors of *O. sinensis* suggested that the government should provide security at the collection sites during the collection season by armed forest department staff in order to secure that only legal collectors entered the areas and to prevent stealing and destruction of tents by competing collectors.

6.1 Sustainability of the harvest

Rising demand for medicinal plants has led to increased pressure on wild plant populations. This, combined with shrinking habitats, means that many species are now facing local extinction (Botha et al., 2004). Legislation has done little to curb the medicinal plant trade historically (Dauskardt 1991). In Bhutan, legislation exists pertaining to the conservation of indigenous plants but implementation is difficult. Illegal collection and trade across the border to Tibet is known to occur but the extent of the illegal harvest and trade has not been estimated. Collectors of *T. matsutake* harvest in shorter periods than the allowed 4 months as the season often started later or finished earlier. For both products, there was a widespread concern among collectors and traders that the current rate of collection is unsustainable and that the two species had become scarcer due to over-exploitation, indiscriminate harvest, and degradation or destruction of habitats. Increased commercialization and globalization of traditional medicines does not invariably lead to declining resources and species loss (Andel and Havinga, 2008). The fact that *O. sinensis* has been collected for centuries and is still common argues for its resilience, but the lack

of harvest studies precludes a definite answer as to whether the harvest can be sustained at its current levels (Cannon et al., 2008). Commercial *T. matsutake* collection in Bhutan began at a much later stage and few studies are available on the amounts collected or biology of the species. Further studies are necessary to determine the ecological effects of this trade. We recommend that for both NTFPs, future management strategies should take into the account local market conditions, and the socio-economic realities facing both collectors and those who depend on the trade for their livelihoods.

6.2 Validity of data

The sample of *O. sinensis* and *T. matsutake* collectors were both skewed towards low income households rendering tests of correlation between income from collection and other income weak. The sample sizes for traders were small ($n=9$ for *O. sinensis* and $n=8$ for *T. matsutake*). Traders' costs for refrigeration, storage space, and losses were not always included as these were hard for traders to estimate. Traders' investment of time was also not included. Several traders stated that they sold less than they bought. It is not known whether the remaining quantities are kept in stock or have been exported illegally. Illegal cross-border trade in *O. sinensis* is known to occur but has not been considered in this study.

7. Conclusion

Collectors' income from *O. sinensis* often accounts for 60-100% of the household's annual cash income while *T. matsutake* accounted for almost 10% of collectors' annual cash income. Incomes from the two NTFPs were not correlated with household income from other sources but both products provided a substantial income-earning opportunity for women and illiterate villagers.

The distribution of incomes in the market was markedly different for the two products. Collectors of *O. sinensis* gain a significantly higher percentage of incomes than *T. matsutake* collectors. There are more actors and levels in the *T. matsutake* trade chain. However, the presence of agents and local retailers does not seem to be exploitative as little margin remains with these groups. On the other hand, the presence of numerous different buyers did not seem to provide collectors a better price through increased competition among buyers as compared to *O. sinensis*.

Though most collectors did not wish for more government intervention in the NTFP trade, they did in many cases expect the government to facilitate infrastructure and a price structure to increase the incomes of NTFP harvesters.

Over-exploitation and habitat destruction was a common concern to collectors of *O. sinensis* and *T. matsutake*. Further research on the biology of the species, the resource base and the impact of increasing collection and trade is needed to ensure sustainable harvest levels.

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