Wild food collection and nutrition under commercial agriculture expansion

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Abstract

Wild food constitutes a substantial part of household food consumption in traditional shifting cultivation systems around the world and significant land use changes will have implications for food and nutrient availability for small-scale farmers. However, with commercial agriculture increasing rapidly in forested tropical regions, many shifting cultivation systems are being transformed from rotational, to continuous farming. Such transformations are not only influencing the kinds of crops grown, but they also affect the availability and use of wild food from the forests, fallows and agricultural fields. Although most research efforts have devoted substantial attention to examine whether commercial agriculture can contribute to eliminating hunger among small-scale farmers as the income gained allows food purchases, they have downplayed the potential impacts on wild food provisioning and overlook a cascade of food security issues related to unbalanced diets that lack nutritional diversity. Rapidly transforming shifting cultivation systems in Southeast Asia provide a unique experimental area to test the ways in which commercial agriculture influences the provisioning of wild food from fallows, forests and fields. These landscapes deliver a diversity of wild foods which many have been exploited by populations to gain part of their subsistence. Using collection diaries and interviews carried out during an agricultural season, we examined the role of forests, fallows and agricultural fields in the provision of wild food in communities in northern Laos characterized by rapid cash crop expansion. We found that wild food from agricultural areas, fallows and forests contributed less to human diets - despite local dietary deficiency problems in those communities having more continuous, rather than rotational commercial agriculture. Although rice shortages decreased when farmer households used their income generated by the commodity crop to purchase rice, protein deficiencies appeared to increase. Our results demonstrate that although the expansion of commercial agriculture in shifting cultivation systems might increase rice sufficiency through an increase in household income, it fails to secure a nutritionally balanced diet and actually threatens it. Therefore, wild food losses may in fact be a direct pathway to protein deficiency and overlooking the diminishing role of wild food in shifting cultivation systems with rapidly expanding commercial agriculture is a major weakness in many research projects examining how commercial agriculture can contribute to eliminating hunger. Our study shows the importance of adopting a more nutrition-sensitive approach to the linkages between commercial agriculture, wild food provisioning, and food security.

Introduction

Commercial agriculture is rapidly increasing in forested tropical regions, thereby transforming many subsistence-oriented shifting cultivation systems towards more commercial agriculture (van Vliet et al. 2012). Several studies have found that economic growth is important for reducing food insecurity and improving the nutritional status of populations (FAO 2015, WFP 2007). However, some of these studies also recognized that economic growth in itself is not enough and that inclusive growth is fundamental for guaranteeing food and nutrition sufficiency improvements (FAO 2015). In fact, the Food and Agriculture Organization of the United Nations (FAO) (2015) has identified situations where the nutritional status failed to improve, despite economic growth. Furthermore, the focus on food security has changed from a primary preoccupation about the sufficiency of staple grains and calories, towards the importance of a balanced diet that includes protein, vitamins and other micronutrients (Pingali et al 2015). This is especially relevant for the poorest part of the world's population (FAO 2015).

Many governments place economic growth high on their agenda, and the Government of Laos is no exception. It is firmly committed to lift Laos out of the ranks of the Least Developed Countries by 2020 and halving the levels of extreme poverty (World Bank 2014). Lao exports are dominated by natural resources (World Bank 2015a) and much of the economic growth in Laos is achieved (as is also planned to be achieved in the future) through foreign and domestic investments –in the agriculture and forestry sectors, as well as in mining and hydropower (GOL 2005, Lestrelin et al 2013, Suhardiman and Giordano 2014). These investments are changing both small farmers´ land use patterns and their access to natural resources. The Government of Laos, like many other governments of developing countries, actively promotes the expansion of cash crop production (Castella et al, 2013, Vongvisouk et al, in review), with the general expectation that modernization and intensification of agriculture should transform the lives of smallholders through a Green Revolution (as happened in many other parts of Southeast Asia in the 1960s onwards). Such transformations of livelihoods are purported to happen through increasing productivity and incomes, thereby widely reducing poverty and increasing the consumption of marketed foods and other goods. The dependence on the immediate surroundings for subsistence livelihoods is thereby assumed to decline, and perhaps eventually leading to a shift away from farming. Throughout Southeast Asia such pushes for increasing cash crop production have been promoted by the support of export crops (Rigg 2005; Barney 2007, Hall 2011; Hall et al 2011).

Land use changes caused by expanding cash crop production are, however, not only influencing local people's income levels and the amount of food purchased, but they also affect the availability of wild food from the forests, fallows, and agricultural fields. The availability of wild food in forest areas is especially assumed to be affected, given that the expansion of cash crop production often comes with deforestation (Krahn 2005; Krahn 2003). Yet, limited attention has been devoted to understanding this intersection between land use change, wild food availability and nutrition. In a recent article, Sibhatu et al. (2015) specifically call for studies that can provide insight into how agriculture and food systems can be made more nutrition-sensitive in particular situations connected to the ongoing land use changes. Therefore, research is urgently needed to identify how cash crop expansion changes local people's collection of wild foods, as well as its implications for nutrient sufficiency, or a balanced diet, especially in settings where it is not possible to purchase varied market food items.

In this paper, we devote specific attention to the shifting cultivation systems of Southeast Asia. Northern Laos was selected as our study site as it provides a unique experimental area to test how cash crop expansion changes people's use of landscape for food provisioning. These landscapes traditionally delivered a broad variety of wild foods, which formed local populations' subsistence. However, during the past 5-10 years they have experienced rapid land use changes from subsistence-oriented rice cultivation to commercial based maize cultivation happening at a very large scale (as documented by Castella et al 2013; Lestrelin et al 2013; Hall 2011; Hett et al 2015; Schönweger et al 2012).

We pose two questions in the article: 1) how does cash crop expansion change local people's use of shifting cultivation landscapes for wild food provisioning?, and 2) how is nutrient sufficiency influenced by changes in the collection of wild food? Our main argument is that commercial agriculture expansion reduces the quality of nutrition when local people rely less on wild food derived from the terrestrial landscape. Herein, we focus on protein, and find that the economic gain from commercial agriculture that would theoretically allow food purchases, does not balance out the loss in protein from wild foods in practice.

Nutrient sensitive landscapes: The intersection between land use change, wild food collection and nutrition

Land use changes within subsistence-oriented landscapes require changes in the way local people secure a sufficient diet, in terms of energy, protein, and micronutrient intake. Thus, we are facing a new set of intersecting challenges, given that land use changes might be demonstrably harmful for local people's diet even though they increase their purchasing power through expanding cash crop production. Unsurprisingly, these links between land use changes on the one hand, and food sufficiency and possible nutrient deficiencies on the other are complex. Yet, the nexus between land use changes and inadequate nutrient intake receives limited attention on the global policy agenda and among scholars. Some attempts have been made to identify a relation between commercial agricultural production and food security (Powell et al. 2015), but these have yielded mixed results. Paddoch and Sunderland (2013) have illustrated that complex landscapes are important for food security at the community level. Despite such efforts, firm evidence from various contexts remains elusive, although Powell et al. (2015) conclude that for developing countries, "*diversity within rural and agricultural landscapes may be an important part of a food environment that supports healthy dietary choices*" (p 535). Yet, they call for more research on how local communities manage their landscapes for supporting healthy diets, or what the Global Nutrition Report (2014) refer to as 'nutrition-sensitive landscapes'. Analogously, Sayer et al. (2013) highlight food security aspects as an important outcome of integrative landscape and land use planning. In the following sections, we elaborate our response to these calls for more research on the intersection between landscape and land use change on the one hand, and food security, nutrient sufficiency and livelihoods on the other.

Economic growth and cash crop expansion

Indeed, economic growth is of great importance to reduce hunger and malnutrition (FAO 2015). The steady decline of undernourished people in Southeast Asia has, for example, been more than halved between 1990 and 2015 and this is largely attributed to economic growth. The trend is similar for Laos and a study by the World Food Program (WFP) (2007) finds a strong, positive effect of household wealth assets on food security.

But the vision of economic growth in Southeast Asia is heavily embedded in large-scale land use changes promoting cash crop production. Such large-scale land use changes have been not only been documented in Laos by several studies (Castella et al 2013;, Dwyer 2011; Lestrelin et al 2013; Hall 2011; Hett et al 2015; Schönweger et al 2012), but several studies (among them Castella et al 2013, Ducourtieux et al 2005, Ducourtieux 2013, Kenney-Lazar 2012) have identified the negative livelihood impacts that land use changes have had for much of the upland population. A "Comprehensive food security and vulnerability analysis" of Lao by WFP (2007) comments that the pressure to change from more subsistence-oriented shifting cultivation to commercial farming, together with the large-scale establishment of plantations and contract farming influence cropping area and biodiversity, actually reduce the contribution of food from the landscape. It is noteworthy that this is a contribution that has been traditionally important, and served as a safety net for local people.

Further, the recent report from FAO (2015) identifies situations where there is an absence of improved nutritional status despite of economic growth. A recent FAO study (2015:26) concludes that "*Economic growth, while a necessary condition for progress in poverty and hunger reduction, especially in the face of an expanding population, is not sufficient. It is inclusive growth that matters*." Likewise, the WFP's Laos Country Strategy 2011-2015 (WFP 2010:14) quotes a study showing that economic growth in Laos has *not* led to a significant reduction in child malnutrition, despite of the downward going trend of undernourishment in Southeast Asia in general as well as in Laos over the past decades.

Food security: More than a question of stable grains

Over the past decades there has been a growing recognition in most parts of the world that food security means more than staple grain sufficiency, and the need for a balanced diet (including protein, vitamins and other micronutrients, in addition to calories) has been brought to the forefront. However, this is less the case in Laos, where food security still is often focused on rice-sufficiency. A recent implementation completion and results report for the World Bank on "Laos Upland Food security improvement project" focuses, for example, on rice sufficiency (World Bank 2015). Although rice-sufficiency is indeed a national and local concern in Laos (e.g. Clendon 2001, who also document villagers' overwhelming concern for rice sufficiency), such a narrow focus fails to take into account diet quality issues.

Wild food: an important source of protein

The lack of attention to diet quality issues is problematic for several reasons. Specific cases substantiate this point. For example, several studies have shown how wild food - especially wild animals (Scoones et al. 1992) –constitutes a substantial part of household food consumption in shifting cultivation systems (Christensen 2002; Cruz Garcia & Price 2012; Fiedler 1994). In such systems a broader understanding of food security is therefore pertinent (Krahn 2005). Krahn (2003:6) pinpoints that "*many wild plant and animal species provide foods with greater nutrient densities than are present in alternative foods imported through market networks in remote mountain areas*". Further, she identifies increased rice consumption and a reduction in meat intake as the greatest nutritional challenge for the Lao Upland population. This is also based on the fact that the traditional diet rich in meat, vegetables and fruit appears to be nutritionally adequate (ibid). Analogously, in a recent article in *Food Security* (2015) Powell and colleagues call for more attention to wild food contribution to overall diets and several studies in Laos have attempted to map the composition of wild food in overall diets (Krahn 2005; Foppes & Ketphanh 2004; Kenichiro et al (2004);

Clendon (2001) and Johnson (2010). The comprehensive food security and vulnerability analysis in Laos by WFP (2007) concludes that "*wild meat and aquatic resources […] are the biggest sources of animal protein in rural Lao PDR. Consumption of domesticated animals cannot currently compensate for a potential loss of access to and availability of wildlife*" (p.1).

The World Food Program (2007) asserts that what differentiates households with acceptable food consumption from households with poor or borderline consumption, is animal protein. If the ongoing land use changes cause declining collection of wild animals, protein deficiencies are a likely outcome and they may outweigh beneficial impacts of increased purchasing power gained through expanding cash crop production.

Schematic outline of the intersection

As illustrated above, there is a substantial knowledge gap about the extent to which land use changes affect local people's consumption of wild food from the terrestrial landscape. As elaborated below, the exploration of this intersection requires consideration of a number of factors.

When cash crop production increases and expands in traditional shifting cultivation systems, changes in several factors may influence well-being and nutritional status of the population. These changes include: (1) land use patterns and frequently associated expansion of agricultural areas that result in changes in the availability of natural resources (e.g., vegetation, ecological habitats and the presence of wild animals and biodiversity), (2) the use of agrochemicals with different environmental consequences, (3) households income levels, (4) people's access to loans and increased risks of indebtedness with the presence of investors, and (5) people's time allocation for different agricultural tasks and patterns of movement throughout the landscape. The different movement patterns are expected to be related to time-constraints due to increased tasks related to cash crop production, but also to changes in household goods such as scooters and tractors, obtained through the increased household income. The changed routes into and through the landscape may also have a bearing on the collection of wild food. Accessing fields by scooter or tractor will not allow farmers to collect wild foods as they used to, given that they no longer walk deliberately through habitats where they formerly collected these foods. The different allocation of time resulting from increased agricultural tasks related to cash crop production may also reduce their attention to collection and hunting in the fields. However, to our knowledge, few studies have assessed how the increased cash crop production influences local people's use of the landscape for wild food provisioning.

All of these changes may influence the collection of wild foods negatively, as the availability of wild foods most likely declines and further they may suddenly contain poison. This applies to wild animals (especially rodents, in the case that rodenticides are used), as well as to wild vegetables and herbs, in case that herbicides are used.

In Laos, the number and area of protected areas have expanded since the establishment of 18 National Protected Areas (NPA) in 1993 (GoL 2005, Moore et al 2012). While these NPAs are sometimes presented as areas that preserve biodiversity and thus help secure livelihood of nearby villages, many villages have experienced restrictions and prohibitions on their historical uses of the flora and fauna in the areas that were converted into protected areas (Moore et al 2012, Johnson 2010). Further, they have lost areas that

were previously part of their agricultural territory, with long fallows in a rotational agricultural system assigned protection status.

Despite the obvious links between land use changes, wild food collection and nutrition, hypothesized relations remain to be tested. Thus, this paper aims to provide empirical insight onthe following hypotheses:

1. *Increased cropping intensity in agricultural system dominated by cash crop production reduces the collection of many pioneer species and wild animals typically found in fields and fallows.* The collection of wild foods from agricultural fields is negatively affected where agrochemicals are applied. Where possible, expansion of cash crop production areas happens at the expense of forest and old fallows and reduces collection and hunting of wild foods from these landscape-categories.
2. *Increase in household income does not necessarily translate into improved quality diet.* Increased household income translates into increased food sufficiency mainly through improved rice sufficiency, comprised of auto-production, borrowing and purchase. Wild animals and wild plants are not purchased. Therefore, the reduction in collection of wild foods associated with the expanding cash crop area has negative implications for nutrient, especially protein, sufficiency.

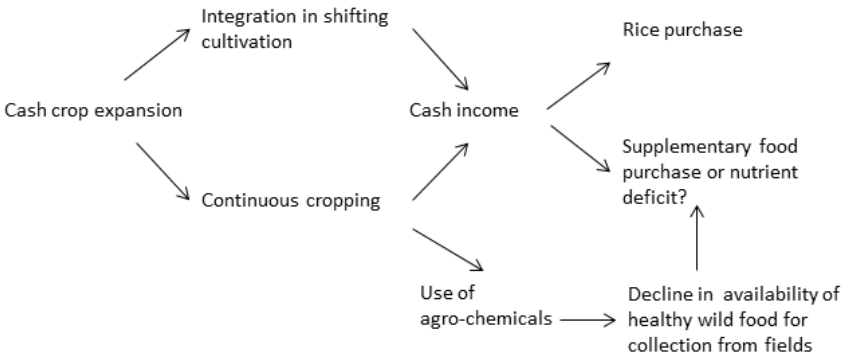

Figure 1: Schematic illustration of working hypothesis

A unique experimental area to test the intersection between land use change, wild food availability and nutrition: northern Laos

The study took place in three villages (Fig. 2), all located in northern Laos in the Huaphan Province and bordering the Nam-Et Phou Louey National Protected Area (NPA). The Huaphan Province represents a particularly interesting case, as the province has been reported to have one of the highest rates of households engaged in the collection of 'non-timber-forest-products' in Laos. At the same time 21% of the households were characterized in 2007 as having either poor (2%, or borderline (19%) food consumption patterns (WFP 2007). Although agricultural production is the main source of sustenance for the population, the promotion of contract farming - initiated by foreign investors from China and Vietnam whose main

interest was maize production- has had profound impacts across the region (Castella et al. 2013, Messerli et al. 2009, Vongvisouk et al. 2014). In fact, there has been an increase in commercial production in all three study villages (Khorn Ngua, Son Koua, and Phon Song) since maize was introduced in 2005, although the increase in production has taken place in very different ways.

The land use system in Khorn Ngua had changed the least and could still be described as being predominantly characterized as traditional shifting cultivation, with most cultivation concentrated on steep slopes. Farmers' main crop was rice, grown in the uplands for 1 to 2 years, after which the fields are left fallow. The cultivated rice fields were the mainstay of the human diet, albeit wild animals and plants also were considered important sources of food. Main trapping and catching techniques for rodents included snares, single-capture traps, and pitfall traps. All members of the household were involved in wild food gathering, while able-bodied adults contributed to the cultivation. The agricultural season included four sub-periods: the slash and burn period lasting from February to April (with a few households burning in May), the planting period from late April to late May, the weeding from late May to late August and the harvesting occurring from September to October/November. No commercially produced fertilizers or pesticides were applied, and maize had begun to be more or less integrated in the shifting cultivation system.

Analogous to Khorn Ngua, the expansion of commercial maize production occurred in Son Koua through integrating maize into the rotational agricultural system. Therefore, it still resembled a traditional shifting cultivation system in many ways. Yet, larger areas were used for agricultural crops and maize cultivation was repeated on the same plot for more years than what is the case for upland rice. However, the village was located close to a paved road implying that the community was more integrated in a larger economic system. For example, the village had been widely promoted as a site for ecotourism. Maize produced in both villages were sold to investors of the cash crop production.

The village of Phon Song was selected to represent a village in which the expanding cash crop production was seen through a land use change from rotational rice cultivation to continuously cultivated maize. The main reason for the continuous cropping was that the Nam-Et Phou Louey NPA surrounded Phon Song, thereby limiting the access to arable land, and not allowing the increase in land under agriculture that was identified in other villages with expanding maize production (Vongvisouk et al, in reviews). It appeared that with the fallow period being omitted in the maize systems of Phon Song, there was uncertainty regarding how long the continuous maize cultivation system could be sustained without causing land degradation. Since the cultivation system no longer allowed natural regeneration, the agricultural season would begin with the burning, rather than slashing, and it ended around October/November when the maize was harvested. The cultivation involved commercial fertilizers and pesticides and the maize was sold to external markets. Analogously to the two other study villages, able-bodied adults were responsible for the cultivation while all members of the household were involved in wild food gathering.

Figure 2: Map of the study sites, northern Laos

Methodology

Three complementary methods - collection diaries, semi-structured interviews and participant observation were employed to examine how the collection of wild food contributed to the diet. We specifically targeted 33 households (11 from each of the three selected village) using these methods. Households were selected to represent fields at short, medium and far away distances from the villages. Data were collected In each village during a four week period, with one week corresponding to each of the four sub-periods of i) slashing and burning; ii) planting; iii) weeding; and iv) harvesting.

Collection diaries

Collection diaries were used to estimate the amount and variety of wild animals and plants collected by households from terrestrial and aquatic habitats. We differentiated between collection from fields, fallows and forest areas for terrestrial habitats. Diaries were chosen as a methodology, given that prior studies had shown their usefulness and high level of detail to explore household consumption of wild vegetables (Christensen 1997, Lykke et al. 2002, Mertz et al. 2001). A research assistant visited participating households every evening during the recording weeks, and together they recorded the products collected, the quantity taken, the location of collection, and the final use of the product. Records were kept on a daily basis for one week in each of the four sub-periods, amounting to 924 household-days of recordings. To account for intra-household variations in collection patterns, all household members were invited to

participate in the evening sessions. If some members were not available, they were asked to tell the participating members prior to the session about their collection for that day.

Daily, rather than weekly recordings, were chosen in order to minimize a memory lapse. Daily visits turned out to prompt a great level of detail, as the products that had been collected during the day often were shown and discussed with the research assistant. The decision to use daily, rather than weekly visits, implied that diaries were kept in four sample weeks, rather than throughout the year, as this would be too costly and cumbersome for households. Sample weeks were distributed during the agricultural season and this helped account for the seasonality of collection patterns. All hunted animals were identified by research assistants to taxonomic group, rather than at the species level.

Semi-structured interviews

When the plots were established in February 2014, semi-structured interviews were conducted with the 33 households in order to obtain information on cultivation practices and the general collection of various items from various habitats. Additionally, households were interviewed a second time after the harvest was completed in order to gather information on the agricultural production, hunting (in the primary forest areas) and to validate the patterns emerging from the collection diaries.

Participant observation

In order to get a better understanding of the products households gathered on their way to and back from the fields, for example, we accompanied each of the households on these walks. This was done four times evenly distributed over the agricultural season, thereby providing a concrete vantage point from which the respondent could describe the products he or she collected. As a result, additional details were often captured, and specific and directly observable matters could be discussed more easily.

Results

When comparing the three study sites, we found a difference in the average cultivated area per households. In Phon Song, the average cultivated area per household was 1.2 ha, while each household on average cultivated 1.3 and 1.9 ha in Son Koua and Khorn Ngua, respectively. This difference is mainly an effect of the NPA total protection zone that surrounds Phon Song and restricts any expansion of the agricultural area.

Household income obtained from expanding cash crop production

When comparing the three study sites, we found that households in Phon Song had a maize-income production (US $ 630 per household per year, Table 1) that was more than doubled the amount earned in the two other study sites (US $ 280 per household per year). However, i the relatively limited income gained from maize n these two villages was slightly offset by the rice production although rice was considered in-kind income.

	Avg. production/HH	*Production value[1]/HH*
Phon Song	~4500 kg maize ~500 kg rice	Maize: ~ US$ 630 Rice: ~ US$ 215 Total: US$ 845
Son Koua	~1000 kg rice ~2000 kg maize	Rice: ~ US$ 430 Maize: ~ US$ 280 Total: US$ 710
Khorn Ngua	~1200 kg rice ~2000 kg maize	Rice: ~ US$ 516 Maize: ~ US$ 280 Total: US$ 796

[1]Estimates based on a maize price of US$ 0.14 per kg and a rice price US$ 0.43 per kg

Table 1: Household production and income from rice and maize respectively.

Wild animal gathering from the terrestrial landscape

Based on the household collection diaries, we found that rats were by far the most frequently gathered animal from the terrestrial ecosystem with 336 individuals collected for the 33 households during the four weeks of reporting.[1]

The diaries showed a rather limited and irregular collection of other wild animals that only added up to smaller quantities of wild protein. Interviews confirmed this pattern of a limited contribution of other wild animals, however, with large variation between household, as those households that specialized in hunting derived other types of animals from the primary forest, as would be expected.

The data showed a limited collection of rats in the village where the agricultural system was almost entirely focused on cash crop production when compared with the two villages in which maize production was more modest (Fig. 3A). Since our sampling design allowed for an estimation of the collection from different landscape habitats (primary forest, old fallows, young fallows and active fields for rice or maize), the results showed that it was the contribution from the active fields that was the most important. The gathering across all villages primarily took place in the agricultural fields, which accounted for 92% and 65% of all records in Khorn Ngua and Son Koua, respectively. Yet, the agricultural fields only contributed half of the collection in Phon Song. The findings thereby illustrate that the inter-village difference was closely related to what went on in the *active fields*, i.e. the rice or maize fields that were being prepared or cultivated by the households, rather than what went on in the fallows or primary forest.

[1] Due to the rather limited collection of other wild animals, our current focus is on rats. However, in future versions of this paper, we'll incorporate our data on collection of e.g. squirrels and bats

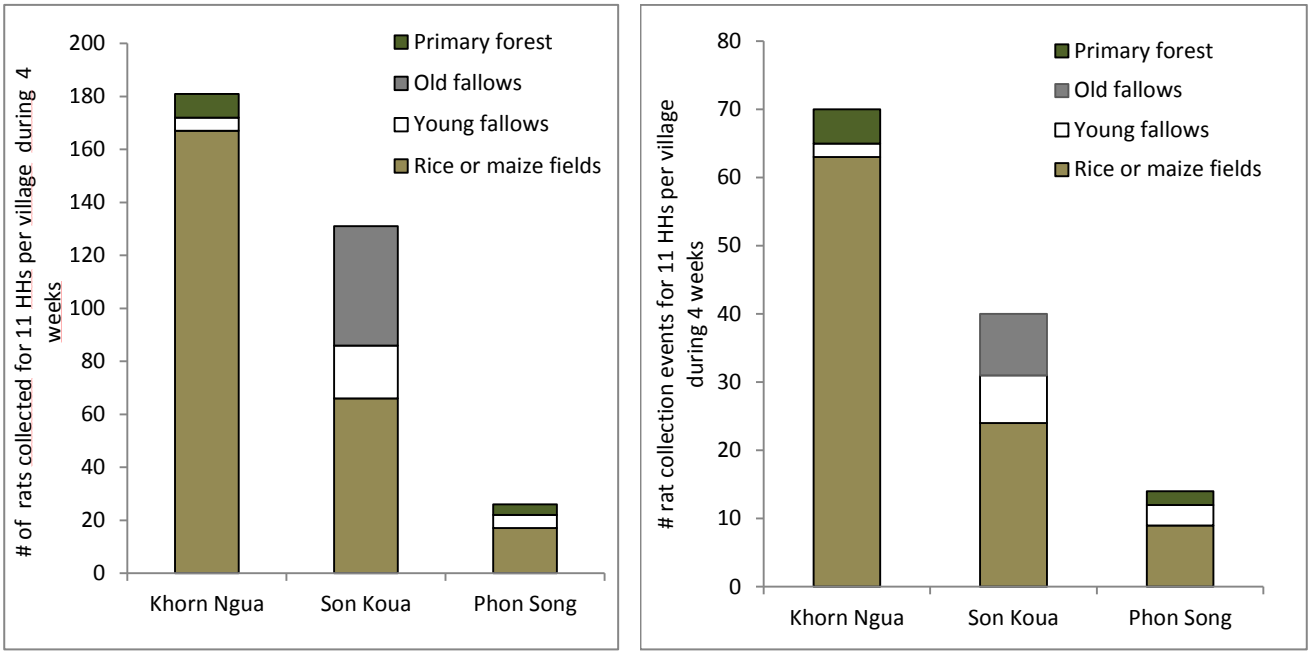

Figure 3: Contribution of different landscape habitats to local people's collection of rats in three villages, Northern Laos. A) # of rats collected, N= 924 household days and 336 rats. B) # of rat collection events, N=924 household days and 125 rat collection events.

Interestingly, we observed the same trend when analysing the number of rat collection events (n=125) (Fig. 3B). While households in Khorn Ngua on average would hunt rats 1.6 times per week, hunting did not even occur at least once every two weeks for Phon Song households, suggesting that not only may the land use have changed the landscape and thereby affected the *availability* of wild foods, but the different land use practices and related tasks may also have changed *people's time allocated* to wild food collection. Another way that the changed land use may have influenced both the number of rats collected and the frequency of rat collection events was through the introduction and use of rodenticides, which made the traditional rat collection unattractive due to fear of poisoning. Rodenticides were introduced in Phon Song, but not in the other two villages.

Protein-gaps

Quantities of collected rats (in grams) were used to estimate the % of required protein intake that was satisfied by the wild food collection from the landscape under the different agricultural systems present in the three study sites.

The calculations presented below were based on the following assumptions: (1) the per capita protein requirement was approximately 50 grams per day (http://iom.nationalacademies.org/Activities/Nutrition/SummaryDRIs) , (2) an average household size is five persons, (3) our estimates of daily rice-intake across the three study sites of 4-500 grams obtained from the interviews, (4) our estimates of rats collected for consumption derived from the collection diaries, and (5) protein levels of 7% and 18% in rice and rats, respectively.

Accounting for the two main protein sources – rice and rats - we found that households faced a 'protein gap' ranging from 9 to 41%. This 'protein-gap' was much more pronounced in Phon Song due to the limited collection of rats from the agricultural fields.

Terrestrial protein sources	*Khorn Ngua*	*Son Koua*	*Phon Song*
Rice[1] protein intake (g) pr. capita pr. day	*28-35*	*28-35*	*28-35*
Rat[2] protein intake (g) pr. capita pr. day	*11*	*8*	*2*
Protein-gap after rice and rat meat intake	*9-23%*	*15-29%*	*27-41%*

n= 924 household-days and 336 rats

[1] Based on a rice intake of 400-500 g pr. capita pr. day and a protein content of 7%

[2] Based on a protein content of 18%

Table 2: Protein derived from rice and rats present in the terrestrial ecosystems of three villages, northern Laos.

As to the question of whether households in Phon Song fulfilled the protein-gap by relying on other sources, the interviews revealed that this was not the case. A number of cases substantiate this point. Firstly, interviews on the reasons for having livestock and their contribution to diets showed that people commonly did not seek to eat them. Rather, the purpose of keeping livestock in these villages was to meet living costs as they arose and pay for weddings etc., while domestic animals were primarily consumed at festivals. Other studies have likewise shown that livestock provide an important, although limited contribution to the diet (Clendon 2001; Krahn 2005; WFP 2007). Secondly, our data obtained from the collection dairies and interviews illustrated that there was very limited hunting of large wild animals. Thirdly, the intuitively appealing assumption that increased income was translated into improved food sufficiency and improved nutritional status makes it relevant to ask whether the identified 'protein-gap' actually was fulfilled by purchase of other sources of protein? Our interviews showed limited purchases of animal protein and in general, they highlighted limited food purchases in all three villages.

Fourth, attention had to be devoted to the protein derived from aquatic habitats, since fish generally are an important source of protein in Laos. Based on the collection diaries, we found that households in Khorn Ngua on average had a fishing frequency of 2.5 times per week during the agricultural season. Analogously to our findings on rat collection events, the frequency was lowest in Phon Song: households' fishing efforts were restricted to once a week. The lower frequency in Phon Song was not outweighed by the amount of fish caught. On the contrary, the amounts caught in Khorn Ngua (820 gram per fishing event) and Son Koua (780 gram per fishing event) were almost twice the amount caught in Phon Song (441 gram per fishing event). When these aquatic protein sources were added to the terrestrial derived protein, we found that the protein intake in Khorn Ngua with the more traditional shifting cultivation system actually matched the protein need (Table 3). In Son Koua, the gap was reduced to less than 15%, but in the village of the Phon Song, a substantial protein-gap was still observed - in the order of 22-36%.

Aquatic protein sources	**Khorn Ngua**	**Son Koua**	**Phon Song**
Fish[1] protein intake (g) pr. capita pr. day	10	6.8	2.5
Protein-gap after rice, rat meat, and fish intake	0-3%	1-15%	22-36%

n= 924 household-days and 240 fishing events

[1]Based on a fish intake of 59, 40, and 15 g pr. capita pr. day for each of the three study sites, respectively, and an estimated protein content of 17% in fish.

Table 3: Protein derived through fish from aquatic ecosystems in three villages, northern Laos.

Finally, one could argue that protein derived from beans and wild greens should be accounted for. Since our interviews did not yield reliable estimates on the amount consumed, we had – for the beans - to rely on a study from the Nam Et Pou Loey NPA (Johnson 2010) which found that families had an intake of 32 grams beans per person per day. Using this figure and a protein content of approximately 3%, we found that the 'protein-gap' declined, but still existed in Son Koua (0-13%) and Phon Song (20-34%).

With regards to wild greens, our data from the collection diaries revealed that households in Khorn Ngua on average collected wild greens four times a week from the agricultural fields. The lowest collection frequency from the agricultural fields was observed in Phon Song (1.9 times per week). Since we identified more than 120 different plant species and a collection event most often entailed collection of a handful of different leaves, it was inherently difficult to translate those wild greens into their respective contribution with regards to protein. However, it is well established that greens contribute an important source of vitamins and micro-nutrients, in addition to some protein (see studies in Powell et al 2015) Based on the number of collection events observed, our findings indicated that the wild greens contributed much more to a diverse diet in the villages with more traditional shifting cultivation agricultural systems, and much less in the village dominated by cash crop production. [2]

Discussion and concluding remarks

The argument in this paper is that commercial agriculture clearly affects the amount of wild food households derive from the landscape when it expands into shifting cultivation systems. If the expansion is happening by a land use change from rice to more continuous maize cultivation, it will indeed limit the amount of wild food that local people can collect from the agricultural fields – which by far is the most important place of collection. Further, if households do not replace the wild food with other protein sources, it may result in a pronounced protein-gap - possibly in the order of 20-34%.

Our empirical findings are supported by Krahn (2005) who found a food consumption pattern in rural Laos that is changing rapidly, among other things with the change in access to and use of natural resources. Although she likewise found that the most 'modern' villages are those with the most inadequate nutrition, she had the dietary changes as a point of departure. Our contribution has been to start from the land use changes and the collection of wild food and then try to draw some conclusions about the changing food consumption.

We see from other studies, that getting sufficient animal protein is a general challenge in this area of Laos. We see that fish and other animals from aquatic habitats provide an important source of protein for the population in the study villages. Yet more protein is needed, and we therefore look at the impact of the change in agricultural production system (from more subsistence-oriented shifting cultivation to a system with considerable production of cash crops for regional or foreign markets) on the collection of protein-rich foods. Consequently, the changes that we observed in the trends regarding the collection of wild foods,

[2] The mode of transportation influences the ease with which a person stops to collect wild food (the faster the mode of transportation, the lesser the tendency to stop). Other studies (e.g. Vongvisouk et al, in review) have shown that much of the increased household income from cash crop production in the area is invested into improved transportation, whether scooters or tractors.

related to the change in agricultural system from shifting cultivation to cash crop production show a potential problem regarding nutrient sufficiency/healthy nutrition.

The localization in different NPA management zones can obviously be expected to influence the level of enforcement of rules (and therefore expecting less hunting in the village located in a pocket inside the total protection zone of the NPA). Yet, often, there are large differences between rules and practices – in many places and also in Laos. Due to the inherently illegal nature of some household activities, households were also assumed to be reluctant to expose exactly where they hunt and collect various products. This hinders any analysis of exactly which part of the landscape was utilized, but we do not expect it to influence the study of wild food collection from existing – and legally used - agricultural land.

Increased use of agro-chemicals (pesticides, herbicides and rodenticides) has clearly limited the collection of for example animals for consumption. We expect the use of agro-chemicals to increase further, with greater cash crop production and contact to traders/investors. This would be an important element to monitor in future research on nutrient-sensitive landscapes, i.e. the impact of the changing land use systems on food security and nutrition. Here, the impact of increased use of agro-chemicals on the aquatic environment and its food provision has to be taken into account as well.

Based on our empirical findings, it is evident that the collection of wild food represents an important source of protein and other nutrients in more traditional shifting cultivation villages. However, the wild food provision from the terrestrial ecosystem appears to be diminishing with increasing cash crop production. Our finding that most of the wild meat is collected from the agricultural fields underpins the argument that changes in the production on those fields, or the use of different inputs on the fields, are the most important elements to monitor in order to understand the implications for the provisioning services from the terrestrial ecosystem with regards to animal protein.

Our empirical focus on shifting cultivation systems in Laos has shown that the current land use changes caused by cash crop expansion are harmful for local people's diet, despite their increasing income obtained through cash crop production. This is partly because alternative protein sources are not available for purchase in the study sites, and because of a change in diet away from the much more diverse wild foods and towards an exclusive rice diet.

Although we found that average household income had increased in areas producing cash crops, our findings clearly highlight that cash income alone cannot be taken as an indicator for household food sufficiency. Indeed, this would overlook potential protein and nutrient deficiencies caused by the declining collection of wild food and the very limited food purchase in many rural villages (both for protein rich foods such as meat and fish and for wild vegetables). While our findings illustrate that rice sufficiency is obtained through a combination of production for auto-consumption, rice purchase and rice borrowing, they also show that the limited food purchases are not enough fulfil the protein-gap caused by the reduced wild food collection.

A landscape approach is important when analysing food sufficiency in areas with expanding cash crop production. We call for attention to the concept of **nutrient-sensitive landscapes** (GNP 2014) for two purposes: First, to acknowledge the intersection between nutrient and diet studies and land use studies,

and secondly, to provide a basis for updating theories of changes about the linkages between land use changes on the one hand, and food sufficiency and possible nutrient deficiencies on the other.

Our study contributes to Sibathu et al (2015)s' call for research that helps provide a better understanding of how agriculture and food systems can be made more nutrition-sensitive in particular situations – in the particular situation of shifting cultivation systems with expanding cash crop production.

We found that the wild food collection from the fields was what had contributed the most to secure protein in local peoples' diet in the more traditional agricultural system. But these wild foods and important protein sources were simultaneously reduced with the expanding cash crop production. We therefore propose that future studies dealing with the intersection between land use changes, nutrition and food security devote specific attention to the contribution of wild food from agricultural fields. Although we do not touch upon it, the potential risks regarding collapse of household income in case of price volatility important aspect of the cash crop expansion to look into in future research. This may affect food sufficiency negatively with potentially severe consequences if collection of wild food is already at a minimum, or if collection is not feasible due to the use of agrochemicals.

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Appendix 1

Land use changes

Our spatial analysis of the land cover changes compares the changes occurred in two periods; the first between 2000 and 2010, and the second between 2010 and 2014. Based on analysis of satellite images, we can identify a decline in old fallows and village forest cover, mainly in the second period, which coincides with the period of time where cash crop production has taken off, after a more modest introduction in 2007 in the area. A generalized change in land use cover can be identified, reflecting changes in the land use and in the agricultural system. The results of the spatial analysis are presented below.

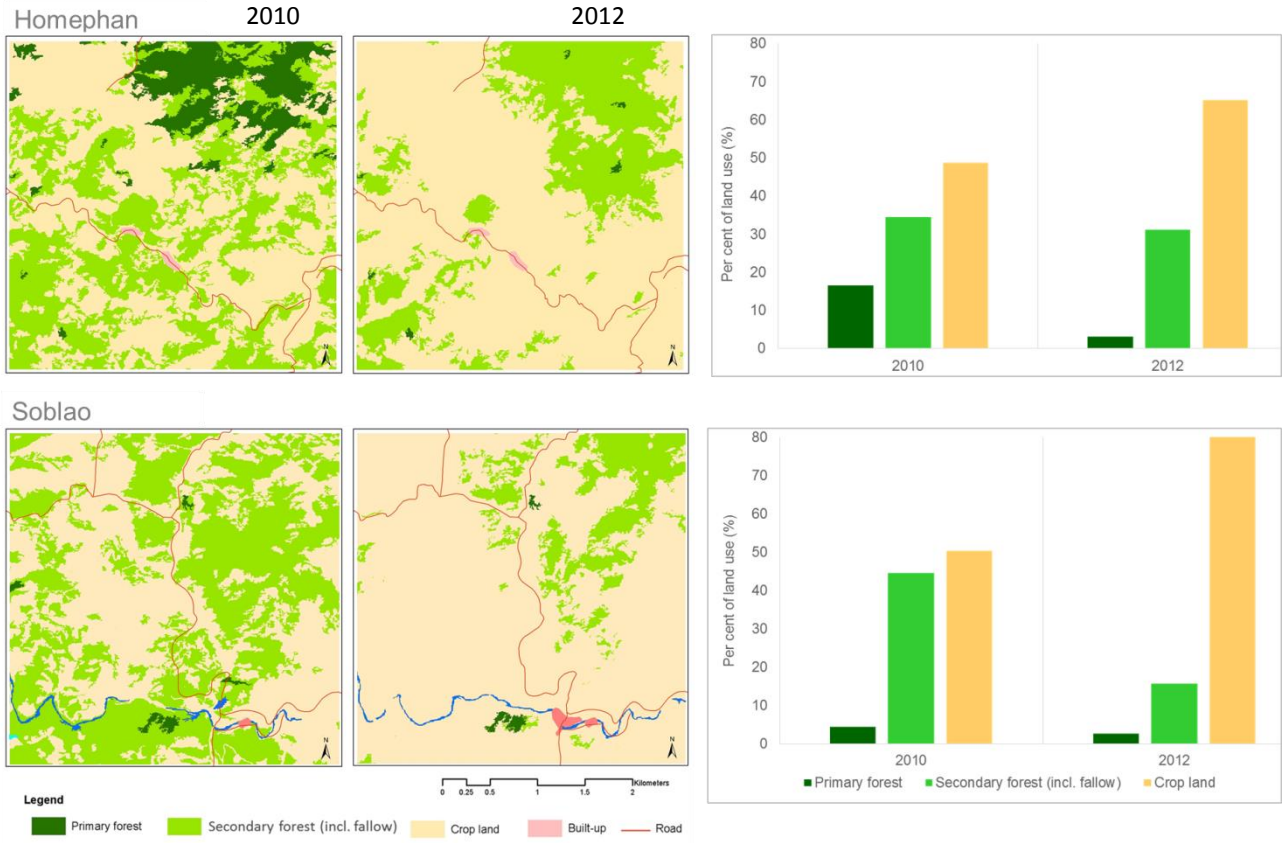

Figure 4: Land use change (2010-2012) [Awaiting finalization of own data – this is from Vongvisouk, Broegaard et al, in review]

[Expected from own data: Land use map. Comparison of two moments in time (2000-2010 and 2010-2014) to show that forest and fallow area is reduced (possibly even within the NPA); and that active cropping area has increased. (Categories: Dense forest, fallow areas, agricultural fields)].