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Swamp buffalo keeping – an out-dated farming activity? A case study in smallholder farming systems in Xishuangbanna, Yunnan Province, PR China

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Abstract

Expansion of rubber tree plantations and agricultural mechanization caused a decline of swamp buffalo numbers in the Naban River National Nature Reserve (NRNNR), Yunnan Province, China. We analysed current use of buffaloes for field work and the recent development of the regional buffalo population, based on interviews with 184 farmers in 2007/2008 and discussions with 62 buffalo keepers in 2009. Three types of NRNNR farms were distinguished, differing mainly in altitude, area under rubber, and involvement in livestock husbandry. While pig based farms (PB; n=37) have abandoned buffalo keeping, 11 % of the rubber based farms (RB; n=71) and 100 % of the livestock-corn based farms (LB; n=76) kept buffaloes in 2008. Herd size was 2.5 ±1.80 (n=84) buffaloes in early 2008 and 2.2 ±1.69 (n=62) in 2009. Field work on own land was the main reason for keeping buffaloes (87.3 %), but lending work buffaloes to neighbours (79.0 %) was also important. Other purposes were transport of goods (16.1 %), buffalo trade (11.3 %) and meat consumption (6.4 %). Buffalo care required 6.2 ±3.00 working hours daily, while annual working time of a buffalo was 294 ±216.6 hours. The area ploughed with buffaloes remained constant during the past 10 years despite an expansion of land cropped per farm. Although further replacement of buffaloes by tractors occurs rapidly, buffaloes still provide cheap work force and buffer risks on poor NRNNR farms. Appropriate advice is needed for improved breeding management to increase the efficiency of buffalo husbandry and provide better opportunities for buffalo meat sale in the region.

Keywords: draught animals, mechanisation, household interviews, quantitative survey, land use change

1 Introduction

In 2009 an estimated number of 188 million buffaloes were kept worldwide, approximately 97 % thereof in Asian countries. Besides the river type, which is dominant in South Asia, the swamp type accounts for 30 % of the total population. Swamp buffaloes are mainly distributed in South East Asian countries (SEA), including southwestern China (FAO, 2012) (for simplified reading, South East Asia and South West China are referred to as SEA+C). While worldwide the total number of buffaloes increased by 12.5 %, the swamp buffalo population decreased by 18.5 % in SEA+C between 1990 and 2002 (FAO, 2012). Among others, possible reasons were agricultural mechanization, poor reproductive performance through insufficient management, and a lack of proper attention by policy makers (Nanda & Nakao, 2003). In history, swamp buffaloes have been a central component of the regional crop-livestock systems by providing draught power, being able to work longer and pull heavier loads than any other draught animal

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available (Nanda & Nakao, 2003). Biological characteristics such as extraordinary heat tolerance (Nanda & Nakao, 2003), and their ability to move safely and pull heavy loads on muddy grounds made them a specialized "working tool" for rain fed and paddy rice systems under humid tropical conditions (Hibler, 2000). Being ruminants, buffaloes are able to convert low quality feed from marginal land, which may remain unutilized otherwise, into high value protein (McDermott *et al.*, 2010). Traditionally milk consumption is very low in SEA+C, but demand increases steadily through the adoption of new consumption patterns. China's overall milk consumption grew by 2.3 % in 2003 (Kurup, 2004) and annual per capita consumption is expected to increase from 6 to 16 kg between 1993 and 2020 (Delgado *et al.*, 1999, 2001). Similarly, meat consumption is expected to increase from 33 to 71 kg per capita (Delgado *et al.*, 1999, 2001) in the same time span; this will not only take place in urban centres, but in rural areas as well (Joshi *et al.*, 2007). Although pork will cover most of the demand for meat (Devendra, 2007), the demand for other types of meat is expected to grow as well, though to a lesser extent. Swamp buffaloes are mainly used as draught animals, while other ways of utilization are only of secondary importance. However, rural development advanced rapidly in many regions of SEA+C in the last decade, therefore the core utilization of the swamp buffalo is seriously challenged by the increasing use of small tractors and other machines for transport and draught power (Liang & Rahman, 1985; FAO, 2002). The global decrease in buffalo numbers, especially in countries with improved rural conditions, seems to prove that the services provided by buffaloes are not required anymore. Nonetheless, many institutions and scientists still valuate them as a very important part of SEA+C smallholder agriculture. As an example, FAO labelled them "an asset undervalued" (FAO, 2000), and many strategy papers conclude with serious appeals to conserve and support buffalo keeping in such systems (Devendra, 2007; FAO, 2000, 2002; Nanda & Nakao, 2003). In the target region of the present study, Xishuangbanna Prefecture in Yunnan Province, South West China, decreasing buffalo numbers were observed. In this the area follows the global trend: buffaloes have lost most of their former importance and may even totally vanish from this area in the near future. Based on two quantitative surveys and a set of group and key person interviews across three different farm types in the target region, this study aimed at understanding past development and current dynamics of the local swamp buffalo population, their present role in the farming systems and for farmers' livelihoods, and their role in the near future.

2 Materials and methods

2.1 Study area

The study was conducted in the Naban River National Nature Reserve (NRNNR), which is located in Xishuangbanna prefecture, Yunnan Province, P.R. China. The prefecture is located in the utmost south Chinese mainland tip, bordered by Lao in the South and Myanmar in the West. The study area is characterized by mountainous topography with lowland plains at 500 m asl and peaks reaching as high as 2300 m asl. The tropical monsoon climate is characterized by two rainy seasons (May–October, and February) and dry, cool winters. Annual average precipitation is 1630 mm, almost all rain falls in the longer rainy season. Overall annual average temperature is 21 °C at lower altitudes, but temperature drops at higher altitudes. Given its unique plant and wild animal diversity, the region was identified as one of the "major biodiversity hotspots in the world" (Myers *et al.*, 2000). The NRNNR itself follows the UNCHR human-nature [1] concept, acknowledging man as part of nature and therefore allowing inhabitants to have moderate impact on their natural environment through settling and agricultural utilization. The area is inhabited by approximately 5500 people distributed across 32 villages. Five major ethnic groups (Han, Dai, Lahu, Hani and Bulang), each with unique language and culture, are found in NRNNR. Similar to many rural areas in China, the study area underwent massive infrastructural improvement in the past few years, turning far off rural dwellers into city-connected parts of society. Quick economic growth and a significant change in agricultural land use through area-wide rubber (*Hevea brasiliensis* L.) cultivation, which started in the late 1960s, resulted in increasing incomes for farmers, but also lead to heavy deforestation and water contamination (Qiu, 2009). However, inhabitants of higher altitudes – traditionally with a large cultural and geographical distance to lowlanders – still are excluded from modernization of infrastructure, agriculture and lifestyles through language and topographic barriers.

2.2 Data collection and analysis

Two surveys were conducted, and additional information was gained through field visits and a series of qualitative group interviews, as well as individual interviews with selected farmers and other stakeholders in the region.

The first survey was conducted between December 2007 and March 2008. Questions to 184 farmers were

[1] http://www.unesco.org/new/en/natural-sciences/environment/ecological-sciences/man-and-biosphere-programme/

targeting general aspects of agricultural activities in NRNNR, and aspects of land and livestock utilization including buffalo herd sizes, and their reproductive, feeding and health management. In addition, socio-economic and cultural issues were covered. A major outcome of this survey was the classification of the dominant farming systems in the NRNNR (Riedel *et al.*, 2012).

The second survey was conducted 12 months later, and 62 (74 %) of the previously identified 84 buffalo keepers out of 184 interviewed farmers in 2008 were interrogated again for further details on buffalo keeping. This survey aimed at understanding farmers' motivations to maintain or abandon buffalo husbandry, the integration of buffaloes in the farming setup, and the time management related to buffalo keeping and using them for labour. For an analysis of long-term developments, historical data on land-use patterns (10 years ago) and buffalo sales prices (5 years ago) were collected as well.

In our data analysis, we present qualitative data to provide an overview on the general buffalo management and the perceptions of buffalo keepers. Quantitative data serve to capture the dynamics of buffalo keeping over time. For comparison of group means, quantitative data were subjected to non-parametric statistical tests (Kruskal-Wallis test and Mann-Whitney U test) using the software package SPSS (2010).

3 Results

3.1 Farming systems

Three major farming systems (Table 1) are prevalent in the study region (Riedel *et al.*, 2012):

1) Rubber-based (RB) farms are mainly located at lower altitudes (800–1200 m asl), and are closest to town. With increasing importance of rubber plantations contributing the greatest share of RB farmers' livelihoods, most alternative agricultural production was abandoned, with small areas of staple crops and a few fattening pigs being the only other agricultural commodities left on RB farms. Only 11 % of RB farms kept buffaloes in 2008.

2) Livestock-corn-based (LB) farms are located at higher altitudes (>1200 m asl) which are characterized by steep slopes and very small field sizes. LB farmers run traditional crop-livestock systems with rice, maize, tea, buffaloes and pigs being the main agricultural products. Buffaloes are regularly used as draught animals on all 76 LB farms.

3) Pig-based (PB) farms represent the interface between RB and LB farms. They are found at all altitudes, have larger rubber plantations and tea fields, and keep more pigs than LB farms, but do not keep buffaloes.

3.2 The use of buffalo

The reason for keeping buffaloes was quite consistent among the interviewed 62 buffalo-keeping farmers: 87.3 % were using them as draught source, for 79.0 % additionally "lending buffaloes to neighbours or families in need" was another major motivation. All respondents who stated to use buffaloes as working animals were using them for ploughing rice and corn fields, and most were using them for harrowing as well (66.1 %). Transporting goods, such as timber or harvested crops, was a reason to keep buffaloes for only 16.1 % of the buffalo keepers; 11.3 % stated that trading buffaloes was a major reason for keeping them and 6.4 % were keeping their animals for own consumption.

3.3 Buffalo herd sizes and herd composition in 2008 and 2009

In 2008, buffalo keeping households kept 2.5 ±1.80 (n=84) buffaloes with an average herd structure of 47 % male and 53 % female animals, 23 % being younger than 2 years (Table 2). The majority (61.3 %) of herds consisted of less than 3 animals.The remaining herds consisted of 6 buffaloes at maximum, except for one herd with 12 animals. In 2009 the average number of buffaloes per farm dropped to 2.2 ±1.69 for all households (n=62).

In 2009, 13.0 % (17.8 % LB and 8.3 % RB farms) of the 62 interviewed buffalo keeping farmers had sold all their buffaloes. Among the LB farmers, 37.9 % kept less buffaloes than in 2008, while 48.3 % had the same number of buffaloes and 13.8 % were keeping more. Comparing the total number of buffaloes recorded in the two surveys, an overall decrease of 21.4 % of the buffalo population was observed. Similarly, but to a lesser extent, the buffalo population on RB farms was reduced by 9.5 % in the course of 12 months. Additionally, two RB farmers stated that they would very soon abandon buffalo keeping and sell all their animals. Informal visits in 2011 confirmed the trend, 4 out of 6 visited farmers had sold all their buffaloes.

3.4 Recent changes in landuse patterns

The general dynamics of the area cultivated per farm, and the developments regarding the area cropped with the five dominant crops are depicted in Table 3. From 1999 to 2009, the total area of cropland per farm increased by 113 % ($p<0.05$) on buffalo-keeping LB farms, and by 99.8 % on buffalo-keeping RB farms. While the area of rubber, tea and other crops (mostly hemp) increased for both farming systems, corn field sizes decreased and the area covered by rice terraces remained constant between 1999 and 2009.

Table 1: *Overall characteristics of smallholder households (HH) in the Naban River National Nature Reserve, and characteristics of the three main farming systems in 2008 (Riedel et al., 2012).*

Farming System	*Altitude* *		*Ethnic Group* †		*Crop area*			*Livestock*		
	% of HH		*% of HH*		*Hectares per HH*		*SD*	*TLU*‡ *(n)*		*SD*
All (n=184)	Low	48.9	Han	21.2	Rubber	1.38	1.675	Buffaloes	0.85	1.287
	Midland	22.8	Dai	19.6	Corn	0.28	0.332	Pigs	0.36	0.310
	Highland	28.3	Lahu	39.7	Tea	0.39	0.591	Sows	0.06	0.065
Rubber based (n=71)	Low	84.5	Han	12.7	Rubber	2.05	1.901	Buffaloes	0.04	0.203
	Midland	9.9	Dai	46.5	Corn	0.09	0.155	Pigs	0.39	0.360
	Highland	5.6	Lahu	29.6	Tea	0.10	0.216	Sows	0.00	0.000
			Hani	8.5						
Livestock-corn based (n=76)	Low	22.4	Han	19.7	Rubber	0.55	0.940	Buffaloes	2.03	1.275
	Midland	26.3	Dai	2.6	Corn	0.49	0.375	Pigs	0.93	0.665
	Highland	51.3	Lahu	57.9	Tea	0.52	0.531	Sows	0.19	0.119
			Hani	19.7						
Pig based (n=37)	Low	35.1	Han	40.5	Rubber	1.81	1.683	Buffaloes	0.00	0.000
	Midland	40.5	Dai	2.7	Corn	0.19	0.220	Pigs	0.96	0.554
	Highland	24.3	Lahu	21.6	Tea	0.69	0.890	Sows	0.21	0.100
			Hani	32.4						

SD = standard deviation
* Altitude: lowland 800–1200 m asl; midland 1201–2100 m asl; highland >2100 m asl.
† Ethnic Group: difference to 100 % is due to some more minor ethnic groups.
‡ TLU: Tropical Livestock Unit, equivalent of an animal of 250 kg live weight (buffalo = 1.2 TLU; pig/sow = 0.1 TLU)

Table 2: *Changes in buffalo numbers in buffalo keeping households (HH) in the Naban River National Nature Reserve from 2008 to 2009.*

Farming System	*HH (n)* 2008 / 2009	*Buffaloes* (n/HH) 2008 Mean	2008 SD	2009 Mean	2009 SD	*Decrease of buffalo numbers* %	*Decrease of herd size per HH* %
Livestock-corn based	76 / 54	2.9	2.23	2.3	1.94	21.4	20.7
Rubber based	8 / 8	1.8	0.62	1.6	0.80	9.5	11.1
Total	84 / 62	2.5	1.80	2.2	1.69	14.6	12.0

SD = standard deviation

3.5 Labour economy of buffalo keeping

Field preparation with the help of buffaloes is carried out between January and June on LB farms and between March and June on RB farms. During the field preparation season farmers keep their buffaloes close to the farm or on nearby fields, while the rest of the year they require feeding either through cut and carry, or guidance to proper grazing grounds, mostly in forest areas. The time investment to guide and herd buffaloes varied strongly, not only among farming systems but among individual households as well. Generally, LB households spent 5.4 ±2.7 hours per day caring for their buffaloes, while 7.0 ±1.4 hours were required on RB farms. Buffalo-related tasks were mostly carried out by older men, women and children. Table 4 displays the average time spent on different herding and feeding activities;

the high standard deviations demonstrate the high variation in the practice of the respective activities which can be described as follows:

- letting buffaloes graze for several days in the forest without watching them;
- fixing buffaloes on harvested rice fields and relocating them several times per day;
- a person is constantly herding buffaloes of one household (HH) for a whole day;
- a person is herding buffaloes from several HH for a whole day;
- a person is guiding buffaloes (of one or more HH) to the forest in the morning and searches and returns them to the farm in the evening;
- buffaloes remain in the stable near the house and receive cut and carry feeding;

The buffalo-keeping farmers conducted all work of field preparation with buffaloes and no machines were additionally used, even if available on farm. No sex preference existed for working buffaloes, male and female animals were used equally for field preparation. A buffalo was used to prepare crop fields for 350 ±200.1 hours per year on LB farms and 92 ±77.7 hours per year on RB farms (Table 5), whereby this includes the animals' resting time on field work days. Based on an standardized eight-hour work day with buffaloes (actual working time per day varied between 6–10 hours), 43 days (LB) and 10 days (RB) were used for ploughing fields with buffaloes. However, this calculation does not include the working hours of shared or hired buffaloes, and average yearly working time per animal might thus be higher in reality.

3.6 *Buffalo marketing*

Sales prices for buffaloes experienced a notable increase during the last years. Although only selling old animals, which are retired from fieldwork and not fattened prior to selling, LB farmers earned on average 2680 RMB (~ 268 Euro) per buffalo in 2003 and 5580 RMB in 2008. RB farmers received 2703 RMB and 6375 RMB per retired buffalo in the respective years. These numbers indicate an overall average price increase of 108 % (83 % when corrected for inflation; WTO, 2012). Buffalo sales prices in 2008 were significantly different from prices in 2003 for each farm type, furthermore the price difference in 2008 differed among the two farm types as well ($p<0.05$).

3.7 *Other buffalo-based outputs*

Following the list of common benefits buffaloes provide to smallholder agricultural systems in South East Asia (Nanda & Nakao, 2003), milk, leather and manure need to be taken into consideration as well, but do not play an important role in the systems analysed here. Buffalo milk has never been utilized and was not considered as product for human consumption by any respondent. Similarly, leather was not produced in the region.

Table 3: *Average area of cultivated land (ha) per buffalo-keeping household (HH, n=62) in the Naban River National Nature Reserve, in 1999 and 2009.*

Farming system		*Livestock-corn based*		*Rubber based*	
Crop	Year	Mean *	SD	Mean *	SD
Rubber	1999	0.0 Aa	0.00	0.4 Ab	0.51
	2009	0.4 Ba	0.86	1.5 Bb	1.87
	change			+275 %	
Tea	1999	0.4 A	0.32	0.2	0.30
	2009	0.8 Ba	0.49	0.2 b	0.31
	change	+100 %		±0 %	
Corn	1999	0.7	0.54	0.5	0.51
	2009	0.5	0.27	0.3	0.39
	change	–29 %		–40 %	
Rice	1999	0.3	0.17	0.2	0.18
	2009	0.3	0.12	0.2	0.16
	change	±0 %		±0 %	
Others	1999	0.1 A	0.18	0.0	0.00
	2009	0.6 Ba	0.21	0.0 b	0.00
	change	+500 %			
Total	1999	1.5 Aa	0.78	1.2 Ab	0.88
	2009	3.2 Ba	1.42	2.4 Bb	1.93
	change	+113 %		+100 %	

SD = standard deviation, * Different superscripts indicate significant differences ($p<0.05$) between years (A, B – in columns), and farm types (a, b – in rows).

Table 4: *Working hours invested each day (h/d) by buffalo-keeping households to herd, guide and feed buffaloes in the Naban River National Nature Reserve in 2009.*

Farming System	*Livestock-corn based* (n=54)		*Rubber based* (n=8)	
Activity	Mean	*SD*	Mean	*SD*
Herding in forest	1.5	2.03	2.1	1.91
Herding in mountains	0.7	1.20	1.1	1.73
Herding in crop fields	2.6	2.03	3.6	1.42
Guiding to grazing grounds	0.6	0.92	0.2	0.41
Forage cut and carry	0.0	0.06	0.0	0.03
Total hours per day	5.4	2.74	7.0	7.42

SD = standard deviation

Table 5: *Annual working time of a buffalo on different types of crop fields in the Naban River National Nature Reserve in 2009.*

Farming System	*Livestock-corn based* (n=54)		*Rubber based* (n=8)	
Working time (h/yr) in	Mean	*SD*	Mean	*SD*
Rice fields	121.4	130.70	37.3	35.50
Corn fields	98.3	56.70	55.0	65.90
Hemp fields	119.3	80.30	–	–
Other crops	11.0	40.70	–	–
All plantations	349.9	200.10	92.3	77.70
Daily working time (h)	1.0	0.50	0.3	0.20

SD = standard deviation

Buffalo skin is rather wasted and only small amounts are deep-fried to serve as snacks for children. In contrast, the initial survey in 2008 revealed that buffalo manure was utilized by 89.4 % of all buffalo keeping farmers across the three identified farm types, and 68 % stated to have need for more manure than available to them. However, at regular field visits during one year it was observed that buffalo manure was usually wasted: buffalo shelters were often built near small water drains and manure was washed away during rains. Only a very low number of buffalo shelters were located near vegetable gardens, so that diluted manure could pass through them when washed into creeks. No incidence of allocating manure to fields was observed during the field stays. The small proportion of buffaloes grazing on rice fields after harvest suggests that their excreta do not have a large impact on soil fertility.

4 Discussion

4.1 Buffalo herd sizes

The average number of animals on buffalo keeping farms in NRNNR agrees with the observation that one single buffalo can serve all work purposes on a 2–3 ha farm in northern China (Thu *et al.*, 1995). Taking into account the animals required for herd restocking, an average of 2 to 3 animals per household seems reasonable. No preference of sex was found for ploughing animals, which agrees with other reports from Asia (Chantalakhana & Bunyavejchewin, 1995; Ranjhan, 2007), although the stronger male draught animals are recommended (Nanda & Nakao, 2003). The sex-ratio in the NRNNR herds however indicates that each farm is maintaining its own breeding unit, which is inefficient and bears the risk of inbreeding. Small genetic pools result in decreasing work power, infertility and disease susceptibility (Burrow, 1998). The reason why every single farmer keeps adult male animals probably is to avoid the reliance on a pregnant female during field preparation time, although this situation could be prevented through proper reproduction management. Optimizing breeding management could also increase the productivity of buffalo keeping in terms of better working ability (durability and power) and higher meat output (Chantalakhana & Bunyavejchewin, 1995). Another aspect when considering productivity is herd size: based on the survey data, there was no difference in labour required for caring for the animals between farms with different herd sizes. If households would double their number of animals, labour requirements would only increase slightly and a higher productivity from buffalo keeping could be gained. This option, however, is only relevant if buffaloes are kept for meat marketing purposes – and it requires secured and adequate forage resources yearround (see below).

4.2 Purposes of buffalo keeping

Traction was found to be the major reason to raise buffaloes, and selling or self consumption of meat were identified as being only additional positive side effects. These findings are congruent with several reports from the SEA+C region. In most surrounding countries buffaloes are kept for the same purpose. In Thailand, for example, about 30 % of all draught power supply on small farms was contributed by buffaloes in the 1990s (Agarwal & Tomar, 1998) and the main purpose for farms in SEA to keep swamp buffaloes still is traction (Perry *et al.*, 2002; Nanda & Nakao, 2003). Informal lending of buffaloes to neighbours was observed by Lawrence & Pearson (2002) in Asia as being common practice, and – although not quantified – was considered to be a significant benefit for poor farmers.

Another aspect of buffalo keeping, which is rather informal and therefore has not been mentioned by farmers, is the social benefit arising from keeping these animals. Often livestock is reported to serve as 'living bank' (Nanda & Nakao, 2003), which can be used to quickly generate cash in emergency cases (e.g., death or sickness of family members; Devendra & Thomas, 2002; Perry *et al.*, 2002). Buffaloes were also reported to gain a 2.6 times higher return on investment when compared to tractors in subsistence farms in Thailand (Thu *et al.*, 1995). The profit is generated through saving fuel costs, higher resale value and the utilization of otherwise useless crop residues. These calculations, however, are solely based on monetary values and do not include labour investment in animal care. The ability of buffaloes to reproduce, contrary to tractors, additionally reduces the farmers' risk. A broken tractor is a total loss, whereas an injured or dead buffalo still will return some money, and through reproduction a replacement will be available after some time without any further investment.

4.3 Work economy

Workload per buffalo per year calculated for NRNNR equals reports from other SEA+C countries. In Thailand, buffaloes are used for ploughing on 146 days per year, and 109 days were reported from Vietnam (Sanh *et al.*, 1995). Comparing labour investment in animal care and return of animal work, each hour of field preparation conducted with a buffalo in NRNNR has the price of 5.6 hours of caring for the animal during the rest of the year, excluding fixed time investment such as training buffaloes and building proper housing. Those 5.6 hours, however, are of lower value than the actual ploughing time, through drastic increase of labour opportunity cost during the field preparation season and the use of "less valued" labour, such as of old household members or women, for herding. Although, when considering labour calculations alone, tractors might be more efficient, the above-mentioned additional advantages of buffaloes still outweigh the labour aspect in subsistence-oriented farms where risk reduction is way more important than optimized short-term economy. More advanced farms, which have more resources to overcome a crisis (e.g., savings, holdings) might consider abandoning buffalo keeping and therewith gain higher labour efficiency.

Although land use patterns underwent massive changes within the last ten years – the average size of cultivated land almost doubled for both farm types still keeping buffaloes – there was no big change in the demand for traction power. A large share of the increase in cultivated land was due to the extension of tea and rubber plantations, while the expansion of the area cultivated with the two major annual crops (rice and corn) remained rather constant (rice) or decreased (corn). Rice terraces which often are situated on very steep hillsides at higher altitudes may by law not be used alternatively and are therefore not expected to vanish in the near future. These fields will continue to require traction input by buffalo draught power in areas where tractors cannot be moved from terrace to terrace. The remaining corn fields are also not expected to be converted into alternative cultivations, since local pig production, mainly relying on corn as feed, is expected to be intensified in the near future (Devendra, 2007). Corn fields, however, are situated on more plain sections where tractors are an appropriate tool for land preparation. Any prediction on the development of mechanized traction therefore should depart from current land-use patterns and their spatial arrangement across plains, slopes and hilltops.

4.4 Meat prices and production

Although meat production is not a main reason for buffalo keeping today, the increasing animal prices, as reported in this study and confirmed for the region by several reports (Nanda & Nakao, 2003; ILRI, 2007), should strengthen the incentive of poorer farmers to produce buffalo meat for the market. Devendra & Thomas (2002) and Liang & Rahman (1985) recommended breeding dual purpose buffaloes which provide similar or better performance in ploughing, and additionally have high slaughter weight and thus will yield high sales prices. The reported price increase for live buffaloes between 2003 and 2008 reflects current developments that are observed in the whole Asian region. Prices as well as demand for meat have grown in the last years and are expected to further increase – at least for another 10 years. However, these demand increases will only have little impact on buffalo meat consumption and will mostly affect pig production in China. Nevertheless, buffalo meat was preferred over pork by richer rural habitants in NRNNR villages, but also by families who recently moved to the nearby town of Jinghong (Riedel *et al.*, 2012), and prices as well as quantity of buffalo meat have increased on the town's wet markets during recent years (own observation). Still, the price per kg buffalo meat was low in the studied farming systems, given that buffaloes are sold at an age of 11 years (Nanda & Nakao, 2003) with a live weight of about 500 kg, the price per kg live weight has only been about 11 RMB in 2008. Compared to this, the live weight price of pigs is above 30 RMB per kg, and about 1200 RMB can be gained from one sow and the respective offspring per year (own calculations). To increase meat production from buffaloes a better management is required, including shorter live spans and purposeful selection of animals. By this, breeding of buffaloes for meat production may become an interesting production branch for farmers who have the possibility to use grazing grounds close to the farm.

4.5 The future of swamp buffaloes in the study region

Our study identified swamp buffaloes as being a major asset for providing draught power on traditional farms, while meat production and trade were of secondary importance. The vast majority (92 %) of the buffalo keepers was found to be poor traditional farmers, whereas in more intensive production systems buffaloes had almost completely been abandoned in favour of tractors. The analysis of publications on buffalo population dynamics in SEA+C countries clearly reveals the interdependency of income level and the size of buffalo populations. While richer countries, such as Malaysia or Thailand, experience decreases in their buffalo numbers (–3 % and –9 % respectively, between 2005 and 2010; FAO, 2012), numbers increase or remain stable in economically weaker countries such as Lao and Bangladesh (+9 % and +22 % respectively, between 2005 and 2010;

FAO, 2012). The example of Thailand further reveals that buffalo meat still is demanded in transition countries, but is obtained from other, poorer regions, where buffaloes are still kept. Thailand annually imports cattle and buffalo meat with an estimated farm gate value of $20 to $25 million from Lao (Chapman, 1995), where buffalo numbers slightly increased in the recent years (see above; FAO, 2012). Extrapolating these observations to Xishuangbanna in China, the following development is expected: lowland (rubber) farmers, who gain economic strength through cash-cropping, abandon buffalo keeping but continue to demand their meat for festivals and other cultural happenings, whereas the buffalo population of subsistence-oriented upland farms (LB type) will remain relatively stable and might gain importance as additional source of income through increasing meat demand from lowlands.

5 Conclusions

Buffaloes still contribute significantly to livelihoods of traditional farm households in South-West China, mainly through provision of draught power at low monetary investment, and through their risk reducing traits. As long as a risk buffer is not provided otherwise, buffalo keeping is recommended for respective farms. Actual trends, however, show that such farms abandon buffalo keeping too early, thereby risking impoverishment in case of shocks (e.g., rapidly increasing fuel prices, such as in 2007/2008). Only if farmers turn towards cash-crop systems, where labour opportunity costs are increasing along with financial revenues, tractors will be the better choice. Appropriate consultation through official institutions is therefore required to convince poor traditional farmers of their buffaloes' benefits. Appropriate breeding management will help to increase the efficiency of buffalo keeping, both in terms of workforce and marketable output of animals and meat. The current farming systems and societal customs also offer an opportunity for increasing buffalo meat production and sale in the study region, but this requires careful animal management including faster growth and earlier slaughter than observed currently.

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