Chapter 4
Grazing Behavior and Local Management of Cattle and Buffaloes in Rural Laos

Masaki Shirai and Satoshi Yokoyama

Abstract Laos presently is undergoing rapid economic development, which is also bringing about changes in the livelihoods of rural residents. While there is concern that these changes will also impact the way in which cattle and water buffalo are kept as livestock, there are few reports in the literature on the grazing behavior of these animals. In this chapter, we report on an ethological study on the spatiotemporal use of swidden fallow in northern Laos by primarily free-grazing cattle and water buffalo. In Kachet village, practicing swidden agriculture in northern Laos, livestock are grazed freely on first-year fallow following swidden agriculture. The results of an ethological survey utilizing global positioning system data loggers indicate that Kachet village offers environments that are suited to the free grazing of cattle and water buffalo. Shorter- and longer-term fallows in Kachet village serve different functions that are presumably necessary for the animals to maintain their body condition. We conclude that the grazing of livestock on swidden fallow constitutes rational use of space created by swidden agriculture. As this practice is well-suited to the villagers' complex livelihood strategy, we must continue to evaluate the advantages of using swidden fallow for livestock grazing.

Keywords Biologging • Geographic information system • Global positioning system • Grazing method • Livestock grazing • Swidden fallow

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4.1 The Importance of Livestock in Developing Countries

When traveling in many developing countries, it is common to see a variety of livestock such as cows sleeping by the roadside or water buffalo wandering around with their calves, just outside of major urban areas. Although it may be hard to imagine from such scenes, to farmers in developing countries, and small-holder farmers in a particular, livestock play diverse roles that are integrated into the daily lives of local residents in their respective regions (Riethmuller 2003). Not only are the meat, milk, and hide of livestock used as products, in regions where daily life is centered around agriculture, for example, livestock are used as draft animals to perform agricultural work, pulling carts, etc. In addition, livestock play a role in local rituals and are featured in the celebrations following such rituals. For this reason, livestock have become an essential part of events such as New Year's or wedding celebrations and funerals. Furthermore, livestock can serve as personal property and can be a source of income since they produce offspring, which can then be sold. In this manner, livestock are a critical element in the conduct of everyday life.

When attempting to understand such animal husbandry in developing countries, it is perhaps important to note that the existing practices are not necessarily sustainable or efficient in terms of animal husbandry. At first glance, it would seem that, if the desired objective is sustainability and efficiency, there is little advantage to raising cattle and water buffalo under semi-wild conditions in which the animals are at risk of attack by wild predators. However, to clarify the advantage of such practices, it is necessary to first understand that animal husbandry in developing countries exists in the context of a "mutual utilization with agriculture" (Takai 2008). In other words, animal husbandry is part of the complex livelihood strategy pursued by local residents, and it is only when one has a bird's-eye-view of these livelihood practices that the advantages of seemingly inefficient animal husbandry practices becomes clear. The following section provides an overview of the current state of and problems associated with animal husbandry in Laos.

4.2 Animal Husbandry in Laos

4.2.1 Cattle and Water Buffalo Grazing

Cattle and water buffalo are the main livestock raised in the Laos (Wilson 2007). Due to differences in resource availability and conditions, the practices employed vary widely from region to region. Takai (2008) and Nonaka et al. (2008) provide detailed accounts of grazing in swidden and paddy rice areas of Laos, respectively. In regions of northern Laos where swidden agriculture is practiced, cattle and water buffalo are grazed on swidden fallow called *Pa Lao*. The herbaceous species-dominated fallows immediately following cultivation feature abundant growth of *Bambusoideae* spp. (known locally as *Nya Nyun*) and *Miscanthus* spp. (known

Fig. 4.1 The grazing of cattle on fallows belonging to Kachet village (Photo by Satoshi Yokoyama in August, 2012)

locally as *Nya Kha*) preferred by livestock, making the land suitable for grazing (Fig. 4.1). As the fallow period increases, the dominant vegetation transitions from herbaceous species to tree-species. Plots that have been left fallow for three or more years are heavily populated with trees and are no longer suitable for grazing by cattle or water buffalo. In northern Laos, swidden agriculture is typically practiced on about 5-year cycle (Roder 1997; Suzuki and Yasui 2002). Cattle and water buffalo are left to graze all day on first- and second-year fallows nestled among a patchwork of swidden fallows in different stages of recovery and featuring trees of varying heights. Such grazing represents a highly extensive practice in which cattle and water buffalo owners simply visit swidden fallows where they graze their animals every few days, walk around to check that their animals are alive, and provide the animals with salt.

Meanwhile, in areas where paddy rice cultivation dominates, different grazing practices are employed during rainy and dry seasons (Nonaka et al. 2008). While rice is under cultivation during the rainy season, owners bring their animals to grazing grounds only in the daytime. This is to prevent cattle and water buffalo from entering paddies where rice is being cultivated. At nighttime, the animals are tethered beneath the raised-floor sheds found on each owner's property (Fig. 4.2). In areas where a double copping is practiced, cattle and water buffalo owners must lead their animals to specific grazing areas year round. In areas where there is no

Fig. 4.2 Tethered cattle in Dong Khuai village (Photo by Satoshi Yokoyama in August, 2011)

second harvest, owners can use the paddy fields for grazing during the dry season, as these fields still contain rice straw. In areas where rice is only cultivated during the rainy season, the use of paddy fields as grazing grounds during the dry season enables farmers to use the dung left by grazing animals as fertilizer.

It is also reported that, in certain areas of northern Laos, cattle, water buffalo, pigs, and poultry are raised in satellite villages known as *Sanam* that are separate from home villages (Nakatsuji 2013). *Sanam*, which are utilized by Khmu people belonging to the Mon-Khmer linguistic group in northern mountainous areas who mainly engage in swidden agriculture, are said to be useful for preventing livestock disease and improving accessibility to grazing lands. As can be seen from the above, cattle and water buffalo have, up to now, been grazed using various methods that are able to co-exist with the livelihood practices of each region.

4.2.2 Changes in Cattle and Water Buffalo Husbandry

While traditional grazing practices continue to be employed, in recent years, livestock owners are facing new challenges resulting from the penetration of the market economy. Figure 4.3 shows the change in number of cattle and water buffalo since 1990. While the number of cattle and water buffalo has been increasing across

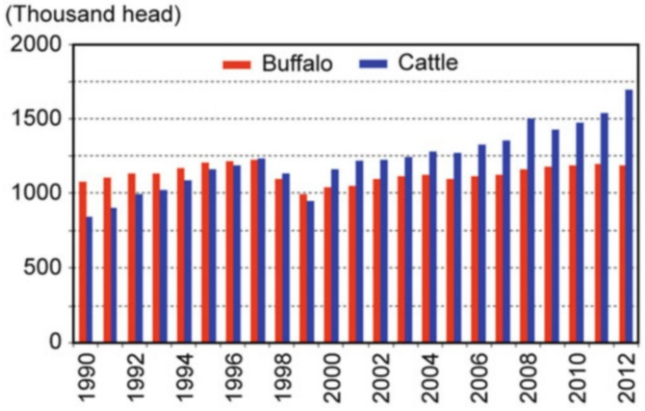

Fig. 4.3 Buffalo and cattle population (Data from National Statistical Center, Laos)

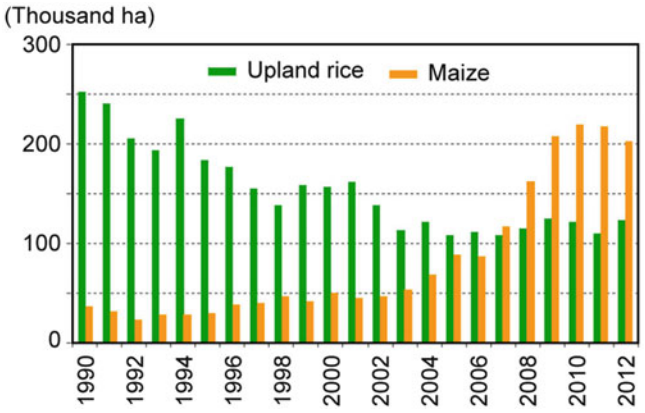

Fig. 4.4 Area of major upland crops (Data from National Statistical Center, Laos)

the whole of Laos, the number of water buffalo has not grown substantially since 2000. Up to now, water buffalo have been kept to help with the plowing of rice paddies. With the widespread use of tractors, however, they are no longer used as draft animals, and their numbers have fallen dramatically, particularly in areas where paddy rice cultivation dominates. According to the Lao Expenditure and Consumption Survey (LECS) household surveys conducted every 5 years by the Lao government, tractor ownership has risen sharply, from 7 % in 1997 (LECS-2), to 19 % in 2002 (LECS-3), and 28 % in 2007 (LECS-4).

At the same time, while cattle and water buffalo in mountainous regions of Laos are typically grazed on fallow lands created by the practice of swidden agriculture, as can be seen in Fig. 4.4, the area under upland rice cultivation has declined

dramatically between 1990 and 2005 indicating that the land under swidden agriculture has been rapidly disappearing. This has resulted in the reduction of grazing land. Since implementation of the Land and Forest Allocation Program (LFAP) in 1996, land use has been tightly restricted (see Chap. 1). Because no land is allocated to swidden agriculture under the LFAP, former swidden lands in mountainous regions have increasingly been converted to upland fields. In swidden lands, the shift from cultivation of upland rice for subsistence to various commercial crops exemplified by maize has occurred especially rapidly since 2003. In addition to maize, the area allocated to para-rubber tree plantations has also increased throughout Laos and the transition to eucalyptus plantations has been especially dramatic in central Laos. Due to a lack of accurate data, however, these trends are not reflected in Fig. 4.4.

Inhabitants of mountain villages in Laos have traditionally adopted complex livelihood strategies, cultivating rice in swidden or paddies while harvesting forest products from the surrounding environment and combining this with the animal husbandry practices described above (Yokoyama 2004). Although subsistence has been the primary objective of such complex livelihood strategies, the establishment of infrastructure that has accompanied economic development has resulted in a shift to monoculture-based land use for the purpose of cash income. As the cultivation of commercial crops and tree plantations has expanded, the incidence of feeding damage caused by livestock grazing has increased and owners of affected farms have started to seek reparation from cattle and water buffalo owners. As such, grazing has become a high-risk practice for the owners of cattle and water buffalo, with the result that a growing number of farmers are opting to get rid of their cattle and water buffalo (Takai and Sibounheuang 2010). In order to prevent feeding damage due to grazing, it is necessary to increase the number of people monitoring the activity of cattle and water buffalo. The decline in swidden agriculture also directly impacts animal husbandry practice by increasing the pool of available labor. It is anticipated that livestock grazing in Laos will have to be practiced under increasingly limited space.

What impact will penetration of the market economy and the accompanying changes in livelihood have on animal husbandry practices? To be able to answer this question, it is first necessary to get an accurate picture of the current state of free grazing with respect to cattle and water buffalo. However, it is unexpectedly difficult to understand the behavior of free-grazing cattle and water buffalo. Grazing grounds are typical located away from villages, and it is not easy, even for villagers, to get a handle on all the activities of livestock that are able to range freely. Furthermore, the presence of observers influences the behavior and ecology of these animals. For this reason, we have not been able, up to this point, to collect detailed information regarding the behavior of free grazing animals. However, with recent advances in electronics, techniques now exist which enable researchers to precisely monitor the activity of animals with minimal interference. Such techniques collectively are referred to as biologging. In the next section, we will introduce several examples of biologging used in ethological research.

4.3 Use of Biologging Techniques in Ethological Research

Continuous observation of animal behavior, not just of livestock, is challenging. Animals encounter and respond to different environments as they move around. In order to adequately understand the relationship between an animal's behavior or ecology and its environment, we need research methods that are not constrained by the limits of human observation. Biologging technologies were developed to be able to continuously monitor animal behavior under conditions in which physical observation is difficult (Naito 2004; Takahashi and Yoda 2010). The term biologging—from the word *bio* (=living organisms) and *logging* (=recording data)—refers to methods that involves attaching small data loggers capable of measuring and recording animal activity and various environmental parameters to animals.

Biologging technology was first developed to help researchers study the diving behavior of seabirds, which, in the realm of bird observation, is considered particularly challenging. Various data loggers have subsequently been developed and improved, so that it is now possible to monitor not only water depth but, also, a variety of other parameters such as location, acceleration, and heart rate, etc. Data loggers have become standard research tools in disciplines involving the study of animal behavior and ecology. The use of biologging in research focusing on livestock has been increasing in recent years. For example, researchers have utilized global positioning system (GPS) data loggers to study the home range of grazing cattle and their preference for different environments (Turner et al. 2000; Putfarken et al. 2008). Heart rate data loggers have been used to study the energy consumption of grazing cattle (Brosh 2007). Acceleration data loggers affixed under cattle chins have been used to collect detailed information regarding the time allocation of different behaviors including browsing, ruminating, and resting (Watanabe et al. 2008). Biologging techniques enable a wide variety of parameters to be measured simply by using different sensors.

Furthermore, the geographic information system (GIS) has been widely adopted in recent years as a tool for analyzing space utilization by animals. Because GIS enables same-dimensional analysis by layering various types of regional data of differing dimensions (points, lines, and planes) on the same map, it expands the applicable range of ethological data and enables interactions between this data and environmental data to be visualized The combination of biologging and GIS techniques has enabled researchers to study animal behavior in spaces that are not readily accessible by people.

In the next section, we describe an ethological study conducted using GPS data loggers and GIS to investigate the spatiotemporal use of swidden fallows and paddy fields by grazing cattle and water buffalo and to clarify how these animals utilize the diverse environments that constitute swidden fallow.

4.4 Ethnological Survey of Free-Grazing Livestock

4.4.1 Survey Objectives and Methods

In order to investigate the behavior of cattle and water buffalo grazed on swidden fallows in Laos, we conducted a GPS data logger-based behavioral survey of cattle and water buffalo in Kachet village (20°34′N, 102°18′E), Luang Phabang province in northern Laos on August 3 and 4, 2011 and from June 25 to 27, 2013. After receiving permission from the livestock owners, we affixed small-form GPS data loggers to the animals (Fig. 4.5) and recorded the animals' locations (latitude, longitude, and time) during the survey period. In this study, we were able to collect data for 16 cattle and 7 water buffalo.

Further, in order to be able to identify unique features of cattle grazing in swidden fallows, we conducted a similar behavioral survey of cattle grazing in paddy fields in Paksuun village (18°17′N, 104°03′E) in Borikhamxay province and Dong Khuai village (18°01′N, 102°48′E) in Vientiane Prefecture, both in central Laos, on August 25 and 26, 2010, and from August 10 to 12, 2012, respectively. We collected data for seven cattle in Paksuun village and one cow in Dong Khuai village.

Using the location (latitude and longitude) data recorded by the GPS data loggers, we calculated the distances between pairs of points and estimated the total distance traveled by each animal during the day. In the case of Kachet and

Fig. 4.5 A cow fitted with a GPS data logger (Photo by Masaki Shirai in June, 2013)

Paksuun villages, in order to identify the points recorded by the GPS data logger concentrated in a small area of land, we calculated utilization distributions using the fixed-kernel density method (Worton 1989). In the kernel density estimation method, the distribution density of location data is treated as a probability density function. By calculating densities within a certain distance from high-density observation points, it is possible to visualize areas in which observations are concentrated. For example, in an area with a 95 % kernel density, it is possible, using the recorded location data, to exclude points within that area that are not utilized by the animal in question. The daytime and nighttime home ranges of cattle in Kachet and Paksuun villages were identified by 95 % fixed kernel density estimation method using the ESRI® ArcGIS 10 Spatial Analyst Density tool. In our study, daytime and nighttime were defined as 0600 to 1829 h and 1830 to 0559 h, respectively, based on the sunrise and sunset times in Vientiane during the survey periods (http://www.timeanddate.com/worldclock/sunrise.html).

4.4.2 Overview of the Study Sites

As in the case of other communities in northern Laos, the villagers of Kachet village practice swidden agriculture. As of 2011, the village comprised 486 individuals from 98 households belonging to the Khmu people. In 2011, the villagers of Kachet village practiced swidden agriculture on a 7-year rotation, and cattle and water buffalo were being grazed on first-year fallows that had been cultivated the previous year. As of 2011, approximately 100 cattle and 15 water buffalo were being kept in the village. By 2013, the number of cattle had fallen to 50 due to losses resulting from a hoof-and-mouth disease epidemic between 2011 and 2012 and selling off.

The villagers of Paksuun village practice agriculture based on paddy rice cultivation. As of 2010, Paksuun village comprised 510 individuals from 104 households belonging to the Lao and Tai Meuiy peoples in the Tai-Kadai language group. Paksuun village is located to the south of the Kading River. The village's cattle and water buffalo are kept on the other side of the river, where they are allowed to graze freely. The land on which the animals were being grazed had been previously used as paddy fields, but were not being used for that purpose in 2010. According to the village chief, approximately 30 cattle and 300 water buffalo were being kept in 2010.

Dong Khuai is a Lao village comprising approximately 1,250 villagers from 260 households practicing paddy rice cultivation (Nonaka 2008). Nearly 1,000 cattle were being kept in the village, with 58.4 % of the households owning an average of 6.7 heads of cattle (Nonaka et al. 2008). The grazing cattle are accompanied primarily by women and children who prevent the cattle from entering the paddy fields during the rainy season (Fig. 4.6). Each day the cattle are grazed in one of four locations, with the location being chosen on daily basis based on the weather and other conditions.

Fig. 4.6 Villagers keeping watch of cattle so that they do not enter the adjacent paddy fields (Photo by Satoshi Yokoyama in August, 2012)

4.4.3 Analysis of Cattle Home Ranges

The home ranges of cattle in Kachet and Paksuun villages, as indicated by the GPS data logger records, are presented in Figs. 4.7 and 4.8, respectively. Both the daytime and nighttime home ranges of cattle in Kachet village were limited, indicating that the animals remain in a small area for a long period of time. In contrast, the daytime home ranges of cattle in Paksuun village were fairly extensive, while the animals spent a substantial amount of time at night in a small area. The limited nighttime home ranges observed in both Kachet and Paksuun villages are consistent with the general observation that cattle are not very active at night (e.g. Ganskopp and Bohnert 2006). The lack of nighttime activity is believed to be an innate protective strategy against predators (Rutter 2006). Although wild cattle in Mexico are known to travel long distances during the nighttime, this may also be a tactic to avoid capture by local ranchers during the daytime (Hernandez et al. 1999). Based on interviews with Kachet villagers, it is known that cattle were lost or harmed as a result of attacks by nocturnal predators such as wolves and tigers up to 2006. Johnson et al. (2006) also documented losses and harm to livestock in Laos due to tiger attacks. As such, the diurnal characteristics of cattle

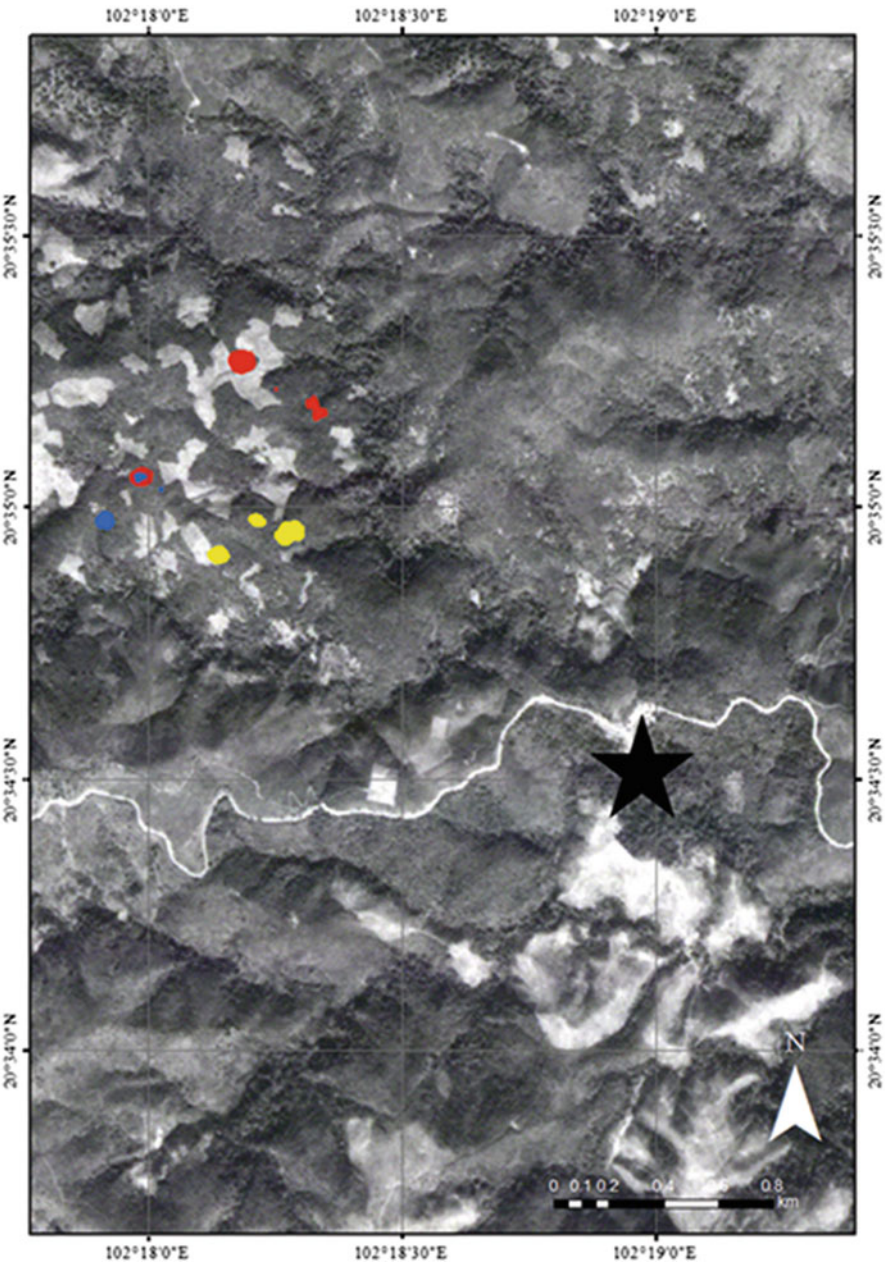

Fig. 4.7 Home ranges of cattle (17 individuals) in Kachet village. *Red areas* represent daytime home ranges (June 26), while *blue* and *yellow areas* represent nighttime home ranges on June 25–26 and June 26–27, respectively. The *star* indicates the location of Kachet village

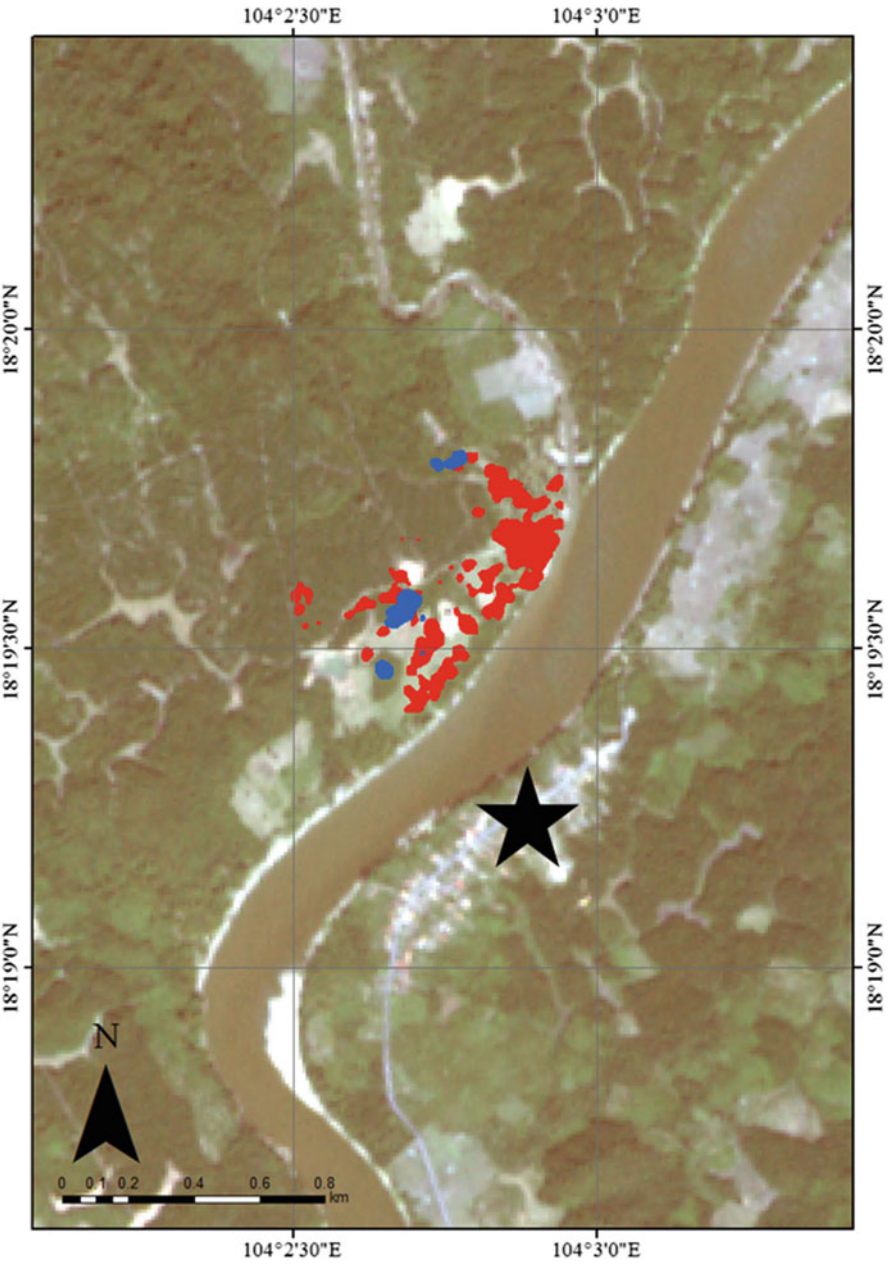

Fig. 4.8 Home ranges of cattle (seven individuals) in Paksuun village. *Red* and *blue areas* represent daytime and nighttime home ranges, respectively

home ranges in Kachet and Paksuun villages may also reflect behavior intended to avoid predation.

The daytime home ranges of cattle were clearly smaller in Kachet village (0.016 km^2) than in Paksuun village (0.109 km^2). The size of an animal's home range (H) is closely related to the animal's energy demand (E) and the productivity of the grazing area (P). In general, a larger home range is necessary to satisfy the higher energy demands of larger animals. Meanwhile, if the productivity of a given grazing area is high, an animal is able to satisfy its needs in a smaller home range. This relationship can be expressed by the following simplified equation (Harestad and Bunnel 1979):

$$H = E/P. \tag{4.1}$$

If we assume that the size and energy demands of cattle in Paksuun and Kachet villages are the same, the differences in daytime home range we observed may reflect differences in the productivity of the villages' respective grazing grounds.

The Kachet villagers are able to regenerate fertile land and increase soil productivity by establishing a 7-year fallow period following swidden agriculture. Furthermore, by using only first-year fallow as grazing grounds, it is ensured that the grazing grounds change each year, which may help prevent a buildup of grazing pressure and enable cattle to continually forage on high-productivity grazing grounds. In contrast, in Paksuun village, the grazing grounds do not change from year to year, resulting in a buildup of grazing pressure over time, which may lower the productivity of the grazing grounds over time.

The results of the behavioral survey using GPS data loggers suggest that swidden fallows are suitable grazing grounds for livestock. Moreover, as the type of grazing practiced in Kachet village does not require the animal owners to perform labor-intensive tasks such as grass-cutting to procure feed, it is advantageous to both animals and people. It is evident from the above that, within the context of swiddeners' complex livelihood strategy, the use of swidden fallows for cattle grazing constitutes an appropriate method for stably raising cattle that allows animal owners to simultaneously perform other livelihood activities.

4.4.4 The Impact of Various Grazing Methods

While the cattle of Kachet and Paksuun villages were allowed to graze both day and night, not all villages in Laos exist in environments where such grazing practice is possible. Each village employs grazing methods that are suited to their immediate surroundings. In order to compare swidden fallow grazing with other grazing methods, we affixed a GPS data logger to one cow in Dong Khuai village (where animals are only grazed during daytime in the rainy season) for 3 days and also accompanied the animal while grazing.

The animal and its owner left home and headed for the grazing grounds at approximately 0800 h in each experimental day. On the way to the grazing grounds, if the animal attempted to enter a paddy field or to eat any crops, the owner would attentively control the animal using a rod or similar item. During the observation period, the animal was grazed in three different grazing grounds (Fig. 4.9). The average distance traveled within a given grazing ground was 2.5 km, which was substantially lower than the average daytime travel distances recorded in Kachet (4.5 km) and Paksuun (3.7 km) villages. Grazing was ended at some point between 1500 and 1700 h, leaving sufficient time for the animal and owner to return home before sunset.

Unlike in Kachet and Paksuun villages, the owners in Dong Khuai village accompanied their grazing animals during the rainy season, and the animals were not allowed to graze at night. Although this strategy is effective in preventing the animals from causing feeding damage, the owners are unable to perform any other livelihood activities during that time. Such limitation on activity may represent a substantial opportunity cost in Laos where many people pursue complex livelihood strategies. Given that the cattle observed in Kachet and Paksuun villages exhibited low nighttime activity, it can be said that the nighttime tethering of animals in Dong Khuai village is consistent with the animals' natural behavioral patterns. Meanwhile, based on past research examining the impact of grazing period on behavior, it is known that shorter grazing periods generally result in higher proportions of time spent grazing and higher intake rates (Ayantunde et al. 2001, 2002). It is believed that this increased intake rate constitutes behavior to compensate for the shorter grazing period (Allden and Whittaker 1970). While it was found that the average distance traveled during daytime grazing was shorter in Dong Khaui than in the other villages, this may be attributable to a higher proportion of time spent grazing.

Because the land available for grazing is decreasing in Laos, it is becoming increasingly difficult to continue practicing free-grazing methods such as those utilized in Kachet and Paksuun villages. Villages that are forced to change their traditional grazing practices will undoubtedly emerge. High-opportunity-cost grazing practices such as that observed in Dong Khuai village may impact the time management of other livelihood activities practiced by the villagers. By identifying the advantages and disadvantages of various grazing practices, it will be increasingly important for villagers to proactively think about what kind of environment they can create for grazing livestock.

4.4.5 Analysis of the Behavioral Rhythms of Water Buffalo

In 2011, water buffalo in Kachet village were grazed all day in and around a first-year swidden fallow located 1.0–2.4 km south of the village. In order to better understand the use of swidden fallows by water buffalo, we delineated a boundary between first-year fallow and other fallows and calculated distance to the boundary

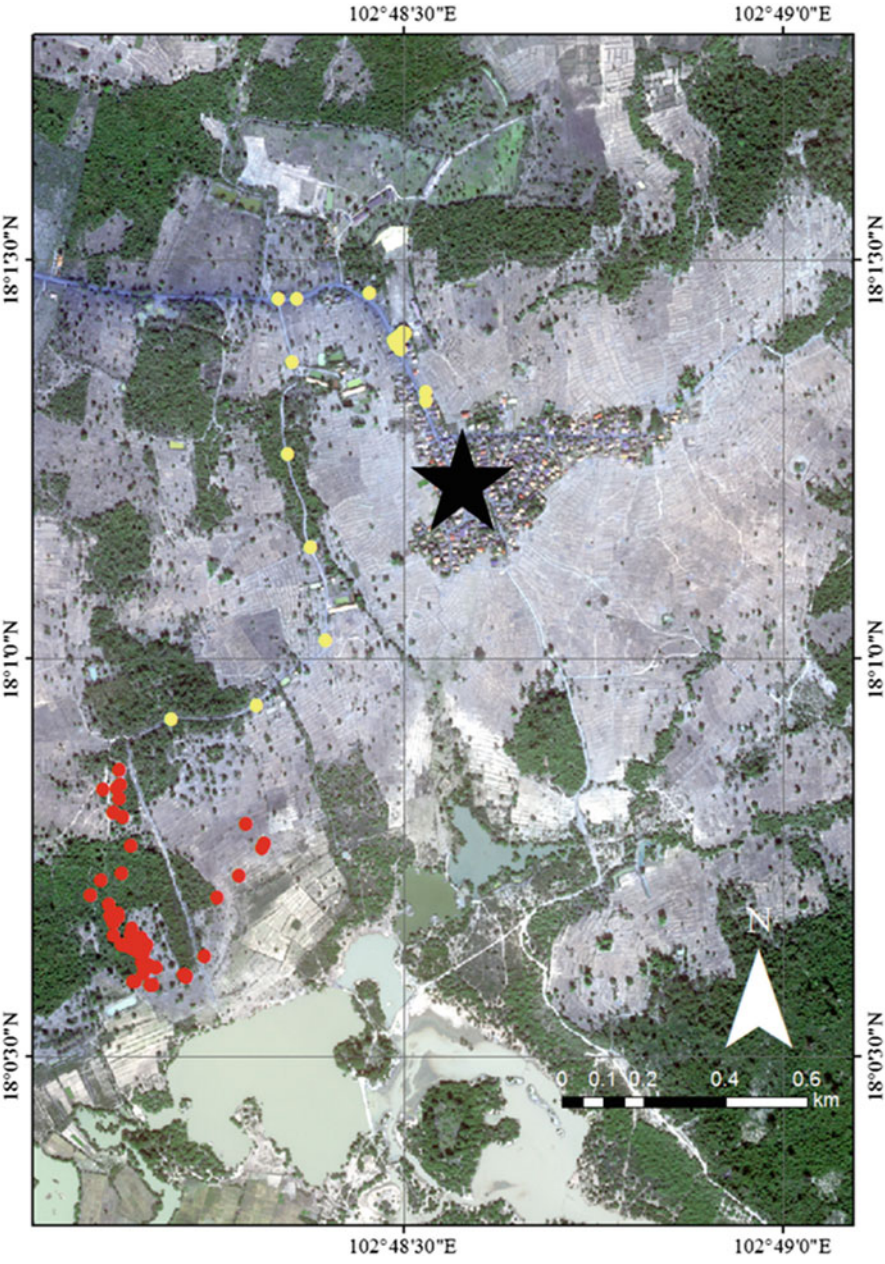

Fig. 4.9 Example of cattle grazing in Dong Khuai village (August 12, 2012). *Red areas* represent cattle locations (as recorded by GPS data loggers) within the grazing grounds, while *yellow areas* represent cattle locations outside the grazing grounds. The *star* indicates the location of Dong Khuai village

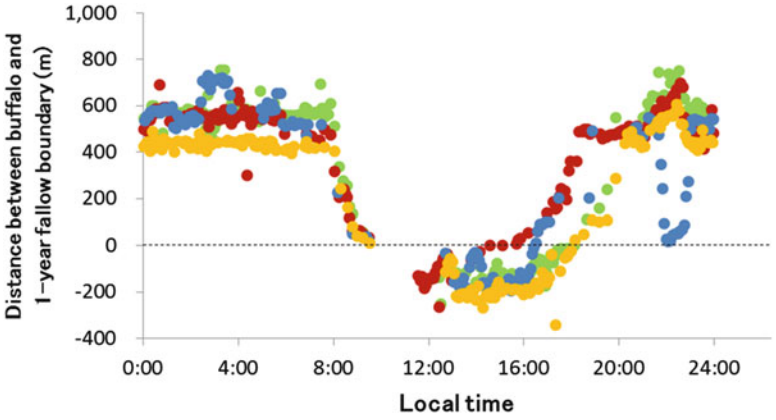

Fig. 4.10 Distance of water buffalo to the first-year fallow boundary by time of day (recorded in 2011). A *positive value* on the vertical axis indicates that the water buffalo was in the first-year fallow, while a *negative value* indicates that it was in the adjacent sixth-year fallow. The *different colors* represent different individuals

over time using the location (latitude and longitude) data from the GPS data loggers. The results of these calculations are presented in Fig. 4.10. The water buffalo spent nighttime in the first-year fallow and daytime in the adjacent sixth-year fallow. Water buffaloes tend to graze at night rather than during the day, which is believed to be related to the difference in magnitude of daytime and nighttime energy and water loss (Sinclair 1977). Because water buffalo have fewer sweat glands than cattle and other mammals, they have poor body temperature regulation (Koga et al. 1998). It is known that water buffalo cope with tropical environments through wallowing behavior in which they cover their entire body surface area with water to promote heat loss (Tulloch and Litchfield 1981). Furthermore, it has been demonstrated that effective use of shade by water buffalo lowers heat stress, rectal temperature, and water consumption (Khongdee et al. 2013). It is possible that the water buffalo observed in our study in 2011 spent daytime in the sixth-year fallow because the greater shade provided by taller trees in the longer fallow enabled the animals to lower their body temperatures. Meanwhile, we believe that the first-year fallow, which offers an abundant supply of the young sprouts preferred by the water buffalo (Momose 2002; Takai 2008), was used during nighttime as a grazing ground. These results suggest that shorter- and longer-term fallows serve different functions for the water buffalo.

In 2013, land adjacent to the village was the first-year fallow and used for grazing water buffalo. The water buffalo serving as our study sample were tethered in the village at nighttime and only allowed to freely graze during daytime. For this reason, we calculated the distance between the animals' daytime locations, as recorded by the GPS data loggers, from the center of Kachet village (Fig. 4.11). While being monitored using GPS data loggers, these water buffalo stayed at a location approximately 800 m from the village during the day and returned to the

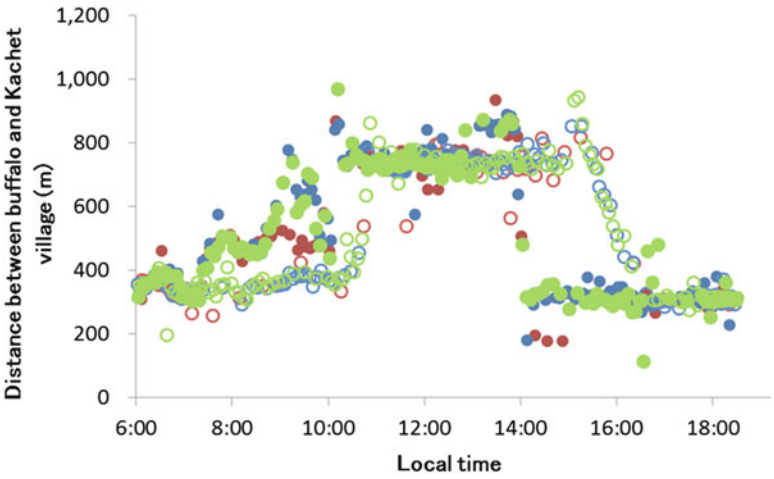

Fig. 4.11 Distance of water buffalo to the center of Kachet village during day-light hours. The *different colors* represent different individuals. The *closed* and *open symbols* represent data recorded on June 26 and June 27, 2013, respectively

village by themselves in the evening. It can be seen that, in contrast to 2011, the water buffalo in 2013 were diurnal, spending daytime in the first-year fallow. This behavior may have been influenced by the fact that the animals were provided water after returning home to their owners. Consistent with our study results, Ryan et al. (2006) reported that water buffalo preferentially use areas within 1 km of a water supply as their home range. The water buffalo may have exhibited diurnal behavior due to the presence of an accessible nighttime water source and a grazing ground (first-year fallow) close to the village.

The above results indicate that water buffalo are able to flexibly adapt to changes in available resources of the surrounding environment. They also suggest that the mosaic of diverse environments that constitute swidden fallow makes it suitable as a grazing ground for water buffalo, which have poor body temperature regulation function.

4.5 The Current State and Challenges Facing Livestock Grazing in Swidden Fallow

We conducted interviews with members of Kachet village, which served as a field site for this study, regarding the grazing of livestock on swidden fallows. It is necessary to provide cattle and water buffalo with salt on a regular basis. In Kachet village, salt was provided to the animals on more or less a daily basis. However, owners rarely entered fallows for the sole purpose of providing their animals with salt and, in most cases, provided salt in passing while carrying out their main task of

collecting forest products. In other words, the harvesting of natural resources, raising of livestock, and cultivating of rice in swidden fields are all elements of the villagers' complex livelihood strategy.

When discussing animal husbandry, the method used to control livestock breeding and reproduction is an important point. In Kachet village, no attempt was made to limit breeding through the use of castration or other means. It is an accepted rule that any calf born belongs to the owner of the cow that bore it. Since one cow generally produces one calf each year, given the presence of 50 head of cattle in the village in 2013, it is expected that there will be 70 head of cattle in the following year. Cash earned from selling livestock is typically used to pay for house construction, bikes or televisions, children's education, or to buy rice. In villages such as Kachet that only have an elementary school, parents must send their children away if they are to continue studying in middle school and beyond. In most cases, the students must board in dormitories in the village where the middle school is located. Parents contrive to obtain the cash needed to pay such dormitories by selling their cattle and water buffalo.

In Kachet village, there have been years (such as 2008 and 2011) in which circumstances have arisen that have prevented swidden burning and, as a consequence, swidden agriculture has not been possible (see Chap. 3). According to interviews with villagers, in such years, the villagers and their children, as a first step, left the village to find work elsewhere and used the money earned to purchase rice. It is only when villagers could not purchase enough rice by such means that they would resort to selling off their cattle and water buffalo to buy rice. This behavior suggests that the villagers do not proactively desire to sell their cattle or water buffalo. Takai (2009) explains that "to the villagers of northern Laos, water buffalo are companions with whom they have formed an ecosystem over many years." It appears that this same mentality is deeply rooted in the minds of the Kachet villagers.

In Kachet village, we observed cattle returning to the village of their own volition every few days after grazing in the first-year fallow. The reason for this is unclear. At times it might be a single animal returning while at others it might be a group of 20 or so animals. Upon confirming that their cattle had returned to the village, the owners would immediately return their animals to the first-year fallow. There were two reasons for this. First, because there is a main road running right next to the village, if cattle are kept in the village, they might be stolen in the middle of the night by people pulling their cars up alongside the road. In addition, the animals are returned to the swidden fallow to lower the risk of accidents involving vehicles and livestock. Second, the villagers have received instructions from government officials to avoid raising livestock in the village itself on hygienic grounds and, thus, try to graze their animals on swidden fallow as much as possible. In this manner, the practice of grazing livestock on swidden fallow away from the village also plays a role in preventing theft and maintaining hygiene.

Meanwhile, the risk of grazing cattle and water buffalo is surfacing. In the past, livestock have been lost or injured as a result of predation by wild animals, with attacks by tigers being confirmed as recently as 1998 and attacks by wolves as

recently as 2006. However, attacks by wild animals have not been confirmed in the past few years. When livestock grazing grounds are adjacent to swidden plots, there is a chance that the livestock will eat the rice crop. In such cases, the villagers cultivating the crops have had to construct fences to prevent the livestock from approaching the swidden plots. In cases where livestock enter a swidden plot even after a fence has been erected, the livestock owner is expected to pay reparations for any feeding damage caused. Takai (2008) provides a detailed account of disputes arising from feeding damage. In Laos, disputes related to feeding damage began to increase in frequency starting around 2000. If livestock enter a field and eat crops after breaking down a fence, it is customary for the livestock owner to pay an equivalent quantity of unhulled rice as the rice that was damaged or lost. Because the livestock owner is only required to pay partial reparation if the fence is found to have been faulty, some farms have begun to enclose their fields with barbed wire. While the use of barbed wire has not yet been observed in Kachet village, it seems there is a need to examine how conflicts between livestock grazing and crop cultivation can be resolved, especially as these become increasingly prominent.

When we visited Kachet village in 2013, we noted that the number of pigs being kept had increased. While the specific price depends on an individual pig's heart girth, a pig can be purchased for approximately 100,000 LAK and sold for as much as 2 million LAK after fattening. It appears that the pig husbandry is increasing in popularity as an alternative to large livestock such as cattle and water buffalo because it requires low initial capital and a reasonable level of investment. With regard to pigs and chickens that can readily be free-ranged or barn-raised even in small spaces, Takai et al. (2008) reported that small-scale animal husbandry remains deeply rooted in farming practice even while land use and lifestyle change. Thus, the raising of pigs may increase in popularity as the difficulties associated with raising cattle and water buffalo increase.

4.6 The Future of Livestock Grazing in Laos

It was demonstrated in our study that Kachet village offers environments that are suited to the free grazing of cattle and water buffalo. Following swidden agriculture, shorter- and longer-term fallows serve different functions for livestock, which are presumably necessary for cattle and water buffalo to maintain their body condition. Compared to other villages in northern Laos that, at present, are only able to maintain fallow periods of 5 years or less (Roder 1997; Suzuki and Yasui 2002), Kachet is able to maintain a relatively long fallow period of 7 years. It is this longer fallow period that enables good grazing grounds to be provided to cattle and water buffalo.

According to the GPS data logger-based ethological survey, the cattle of Kachet village congregate and spend long periods of time in a single location during the day. This observation indicates that the cattle of Kachet village do not need to move around to find food. In contrast, cattle in Paksuun village had more extensive home

ranges than cattle in Kachet village and moved about to look for food. It is believed that these different cattle behaviors reflect differences in productivity of their respective grazing grounds. It is likely that Kachet village, which changes grazing grounds and swidden fields every year, is able to maintain higher-quality grazing grounds than Paksuun village, which grazes livestock in the same location year after year. Similarly, in Dong Khuai village, where livestock owners change cattle grazing grounds every day, it is believed that the rotation of grazing grounds is important for maintaining their productivity (Walton et al. 1981). The challenge of sustainably using livestock grazing grounds is related to the question of how grazing is managed. While the sustainability of grazing grounds varies depending on grazing method, among the methods discussed above, it is apparent that the use of swidden fallow is highly sustainable.

Meanwhile, considering the urbanization and changes in land use that are occurring in Laos, it can be predicted that the current cattle and water buffalo grazing practices on swidden fallow will become more difficult in the future. Even in Kachet village, which had maintained fallow periods of 8–15 years prior to 1996, fallow periods have become shorter due to the recent increases in population (see Chap. 6). If this trend continues, it is possible that the areas with tall trees utilized by water buffalo will be lost. In addition, in our interviews with villagers, we were able to catch glimpses of conflict between crop cultivation and grazing even in Kachet village. Such circumstances could potentially lead to social changes that abruptly alter the environment in which cattle and water buffalo are raised. The reported decrease in numbers of water buffalo being kept in northern Laos reflects the increasing difficulty associated with raising water buffalo that has resulted from not only changes in the natural environment but, also, changes in the social environment (Takai and Sibounheuang 2010).

The results of our study suggest that swidden fallows (a) are relatively more productive and constitute favorable grazing grounds for livestock and (b) enable villagers to graze their livestock with minimal effort. Swidden agriculture represents an agricultural system that utilizes the power of nature to cultivate crops in a sustainable and cyclical manner. In addition to serving as a location for food production immediately after burning, swidden land that is left fallow continues to serve as a location for harvesting forest products and for performing other livelihood activities (Yokoyama 2013). Our study results indicate that the grazing of livestock on swidden fallows is a rational way to utilize swidden space. The practice of grazing livestock on swidden fallows is not very efficient when compared to the integrated grazing systems employed in advanced countries. However, it is a practice that is extremely well-suited to the villagers' complex livelihood strategy. We must re-evaluate grazing methods after first understanding the value of such methods. The environmental and social problems associated with efforts to continue grazing livestock on swidden fallows are, by no means, few. In order to resolve these problems, it is necessary to clarify the various advantages of such grazing practices.

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