Human Ecology (2022) 50:697–710
https://doi.org/10.1007/s10745-022-00327-3

Spatial and Temporal Patterns of Large Mammal Hunting in a Changing Swidden System of Arunachal Pradesh, India

Anirban Datta-Roy[1]

Accepted: 26 April 2022 / Published online: 9 August 2022

Abstract
The hunting of wildlife is a contentious issue that conservationists see as the biggest threat to biodiversity. At the same time, forest-dwelling indigenous tribes depend on it for various socioeconomic and cultural needs. Lack of data on hunting offtakes, and spatial and temporal patterns of hunting have hindered a detailed understanding of these activities, especially in swidden landscapes. I documented spatial and temporal patterns of large mammal subsistence hunting among an Adi village of Arunachal Pradesh over 22 months. Results show that secondary forests and swidden fallows within 6 km from the village are critical areas for hunters, contributing 45% of hunted animals and accounting for 56% of total biomass extracted. This 'garden hunting' highlights the importance of swidden landscapes for hunters and anthropogenic fauna like barking deer (*Muntiacus muntjak*) and wild pig (*Sus scrofa*). Maintenance of swidden landscapes that allow garden hunting appears crucial to reducing hunting pressure on nearby undisturbed forests.

Keywords Garden hunting · Subsistence hunting · Hunting patterns · Shifting cultivation · Northeast India

Introduction

The hunting of large mammals and the impact of their decline on overall biodiversity loss have received significant attention in recent times (Dirzo et al., 2014). Increasing harvest of animals within limited areas has been found to exert greater pressure on surviving wildlife populations that are not compatible with sustainable extraction levels (Hill & Padwe, 2000; Mena et al., 2000; Robinson & Bennett, 2000a, 2000b). This has led to concerns over species extinctions and the resultant ecological cascade effect (Dirzo & Miranda, 1991; Estes et al., 2011; Nichols et al., 2009; Roldán & Simonetti, 2001). Unsustainable hunting in species-rich tropical forests is one of the primary threats to biodiversity conservation (Fa et al., 2014; Hilton-Taylor & Stuart, 2009; Milner-Gulland, 2003; Peres et al., 2010; Wilkie & Carpenter, 1999). Impacts of such unsustainable hunting may not always be evident as, unlike the visible effects of habitat loss and degradation, 'hidden effects of faunal loss' cannot be mapped and detected by remote sensing approaches (Wilkie et al., 2011).

Many people in the tropics also depend on wild meat as a source of protein and income, making hunting a gap-filling subsistence activity that has low economic importance but high importance in rural household diets (Bennett et al., 2002; Milner-Gulland, 2003; Nielsen et al., 2018). Across the tropics, there is also an overlap between the dwelling areas of indigenous people dependent on the forests and areas of high species diversity and abundance (Gorenflo et al., 2012). This ensures that the livelihoods of indigenous people and how they utilise faunal resources have been under constant scrutiny and legal restrictions (Constantino et al., 2008; Peres & Nascimento, 2006; Smith, 2008). The predominant view of faunal extraction by indigenous groups has been that it results in overhunting which eventually leads to the loss of biodiversity (Hames & Raymond, 2007; Smith & Wishnie, 2000). On the other hand, studies demonstrate that local people have managed their land such that biodiversity has not just remained intact, but may also have increased because of human modifications to the habitat (Alcorn, 1993; Schwartzman & Zimmerman, 2005). This has allowed them to harvest animals from these modified landscapes consistently. Recent work also calls for greater attention

✉ Anirban Datta-Roy
anirban.d.roy@gmail.com

[1] Foundation for Ecological Security, Guwahati, Assam 781024, India

and legitimacy to subsistence hunting, accounting for its importance to marginalized communities from different cultural backgrounds (van Vliet et al., 2019; Antunes et al., 2019).

Northeast India, consisting largely of mountain ranges, is an area of high faunal and floral richness and is part of a global biodiversity hotspot (Myers et al., 2000). Indigenous tribes inhabiting this region have practiced subsistence hunting and trapping for generations along with swidden cultivation. Wild animals are regularly used for food, rituals, and medicine, with hunting also playing a role in controlling crop predators near swidden fields (Aiyadurai, 2011; Datta, 2002; Elwin, 1960). Subsistence hunting and trapping have been an integral part of the economic and cultural lives of the indigenous tribes, and the implementation of hunting restrictions through the Wild Life (Protection) Act of 1972 has not been particularly effective (Datta, 2007). Most forests in the northeast states are managed by communities themselves, with traditional institutions playing an important role in the utilisation of natural resources, including hunting and trapping (Poffenberger, 2006). Community control of forests presents a challenge for India's strict wildlife laws that are influenced by the colonial approach of restricting and criminalizing native utilisation of forest resources.

Early studies on village hunting in India were conducted in the Western Ghats to evaluate the faunal presence and understand hunting techniques (Madhusudan & Karanth, 2002; Kumara & Singh, 2004). In the eastern Himalayas, studies have used questionnaires, market surveys and interviews to comment on hunting practices among tribal communities (Hilaluddin et al., 2005; Aiyadurai et al., 2010; Chutia, 2010; Velho & Laurance, 2013; Bhupathy et al., 2013). Apart from studies focused on hunting, most faunal surveys refer to hunting through anecdotal information as an activity that poses a threat to the rare fauna of the region. A few studies have used ecological field methods and camera trapping to understand the impact of hunting in village forests and protected areas (Datta, 2002; Datta et al., 2008). With a few exceptions (Aiyadurai et al., 2010; Dollo et al., 2010; Nijhawan & Mihu, 2020), cultural and socioeconomic aspects of hunting among the tribes of the region have not been explored. To bridge this gap, there have been calls to explore the relationship between forests and people with a focus on hunting through interdisciplinary studies (Aiyadurai, 2011). While legal provisions in the northeast provide communities the right to manage their lands through local institutions, there is still very little understanding of how that applies to the regulation of hunting. Significantly, there have also been no studies on spatial, temporal patterns or offtakes from subsistence hunting anywhere in India.

Across the world, spatial aspects of hunting are one of the least studied issues (Dunn & Smith, 2011; Read et al., 2010). Factors affecting hunters' choices of where to hunt can eventually have implications for the dynamics of animal populations and need to be incorporated into studies of hunting patterns (Dudley et al., 2009; Naranjo & Bodmer, 2007). The scarcity of such studies is ascribed to logistical issues and the variability inherent in spatial aspects of hunting across regions (Read et al., 2010). However, many indigenous groups may already be managing their landscapes to accommodate spatial hunting strategies that are appropriate for maintaining prey populations. My study investigates the spatial and temporal patterns of large mammal subsistence hunting in an upland swidden landscape and also focuses on the traditional institutional management mechanisms that allow regulation of hunting and trapping. Through this work, I intend to highlight the importance of swidden landscapes as areas of conservation significance as well as livelihood importance.

Study Area

The study was conducted in the district of Upper Siang in the state of Arunachal Pradesh, with fieldwork situated in the study village of Bomdo, consisting of 75 households. Upper Siang is one of the northern districts of Arunachal Pradesh which shares a rugged, mountainous border with China from where the Tsangpo River enters India as the Siang (Fig. 1). The district has one of the lowest population densities in the country of 5.4 persons per sq. km. and is inhabited by people belonging to the Adi tribe. Villages are mostly situated in the river valleys with habitations confined primarily between 500 m above sea level–1500 m above sea level. The vegetation of the region has been classified into Temperate broadleaved, Temperate coniferous, Temperate scrub, Tropical semi evergreen, Tropical evergreen, Subtropical broadleaved, Secondary forests and Bamboo breaks (Haridasan et al., 1999; Singh et al., 2005). The region falls within the eastern Himalayas biodiversity hotspot and the biodiversity of the region still remains relatively unexplored although the few surveys conducted here have revealed its potential (Datta-Roy et al., 2018; Haridasan et al., 1999; Katti et al., 1990; Naoroji & Sangha, 2006; Newton, 2002; Pawar & Birand, 2001; Tamang et al., 2006).

Villages are commonly surrounded by a matrix of secondary forests, agricultural plots and differently aged fallows, characteristic of swidden landscapes in south and southeast Asian highland tropics. Primary livelihood activities include swidden and terrace cultivation along with hunting, fishing and collection of minor forest products. Swidden cultivation allows the people to grow local varieties of rice, millets and vegetables that are used exclusively for subsistence. Swidden has gradually been replaced in pockets by terraced paddy and is undergoing a transition to more intensive forms of cultivation through government schemes and policies

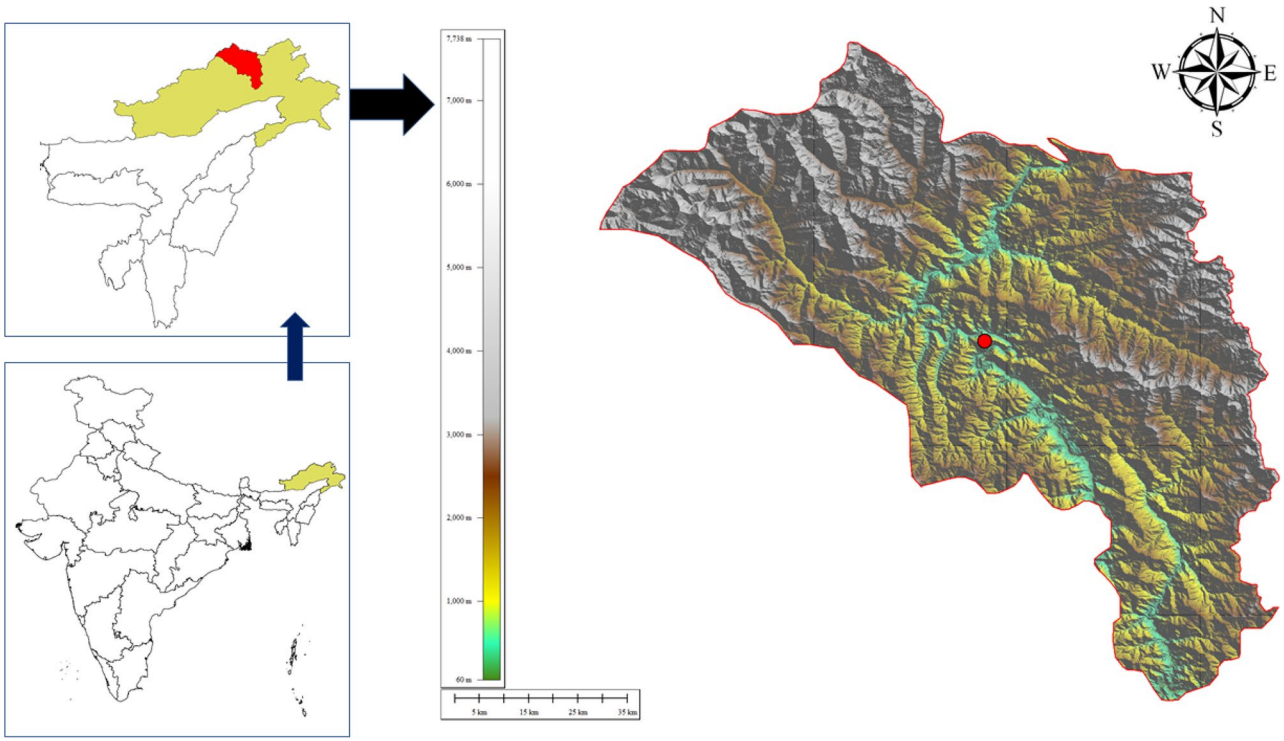

Fig. 1 Location of study village in Upper Siang district of the state of Arunachal Pradesh, India

(Teegalapalli & Datta, 2016). People also raise pigs, chicken and goats in the village while the semi domesticated bovid, the mithun (*Bos frontalis*) is an integral part of their cultural and socioeconomic lives. A system of social norms and customs are maintained by a traditional local institution, the *kebang* composed of village elders. A majority of the Adi people subscribe to their traditional animistic beliefs which are now collectively termed as the Donyi-Polo belief system.

Methods

The study presented here relates only to the hunting and trapping of large mammals in the village forests. I do not present information on small and medium-sized mammals and bird hunting as there is no comparable spatial and temporal data for them. I also do not present information on hunting of the large mammal Takin (*Budorcas taxicolor*) which occurs once a year for a limited period, but is spatially unique in being conducted outside the contiguous territory of the village (Datta-Roy, 2018). As mentioned earlier, large mammals are culturally and practically preferred by hunters and were chosen for intensive investigation. I obtained spatial and temporal hunting data of all large mammal hunts for a period of 22 months (May 2012–February 2014) across two hunting seasons from 28 different hunters.

Participatory Mapping of Village Hunting Areas

Village lands used for hunting, trapping and swidden agriculture are divided among clans and households and are familiar to villagers through their local names. Information on the extent and nomenclature of these patches were physically mapped with a GPS and then transferred onto a GIS platform to create a consolidated map that involved local names georeferenced on a vector layer. This provided a common platform between hunters and researchers to designate specific (hunting/trapping) locations within the landscape.

Offtake Monitoring for Spatial and Temporal Data

For research on hunting patterns, an offtake monitoring system was set up in the study village that was based on self-reporting of real-time data. This was possible due to a high level of trust and cooperation from the villagers based on the researcher's permanent presence, active participation in village activities and extensive discussions with hunters and other villagers to allay doubts related to the study. Self-reporting provided the most accurate and complete information on hunting since it is reported on the day when the hunt is conducted. Whenever a medium to large sized mammal (> 10 kg) was hunted, hunters were approached at their homes and relevant details (location of the hunt, method of hunting/trapping, species, age, sex, approximate

weight) were recorded. The reporting system provided information on the hunting patterns of the village for a period of 22 months (May 2012–February 2014) across two hunting seasons. During the researcher's seasonal absence from the village (during the monsoon and summer), this information was collected and compiled by a trained field assistant who was also a hunter in the village.

Interviews and Participant Observation for Hunting Practice and Regulation

Open ended semi-structured interviews were conducted with experienced hunters in the village to gather information on hunting and trapping techniques, beliefs, experiences and regulations. A few hunter-follows were conducted, primarily to record trapping methods. The constant presence of the researcher in the study village over five years allowed close relationships with many of the senior hunters who were open to sharing their knowledge and experience of hunting and fauna. Apart from interviews with regular hunters, interviews were conducted with seasonal rodent and bird trappers, who would typically not participate in large mammal hunts. Throughout the research period, participant observation and non-formal group discussions added to the understanding of local rules, institutions and hunting practices. Spiritual and cultural aspects were also discussed with elders and village shaman as part of a larger research project.

Data Analysis

Spatial patterns of hunting and trapping during the study period were visualised by plotting hunt/trap locations on a georeferenced landuse map. I used QGIS version 2.14.0 (Quantum GIS Development Team, 2015) and Global Mapper version 15 (Blue Marble Geographics, 2013) to plot the distribution of hunting and trapping locations with reference to distance from village and landuse categories differentiating forest and agricultural areas.

Results

Hunting Strategies and Technology

Large mammal hunting strategies among the Adi can broadly be divided into two major categories on the basis of the technology used for hunting–active hunting with guns and passive trapping through snares. Both these strategies are used by hunters to hunt the common prey such as barking deer, wild pig, Himalayan serow (*Capricornis thar*) and Himalayan black bear (*Ursus thibet*anus) within the village territories. Circumstances such as time of the year also influence the choice of hunting strategy. Hunting of the Takin, a high altitude goat-antelope that is found only in the eastern Himalayas is notable because it is never hunted through trapping. Hunters did not report any active manipulation of forest areas around the village to attract large mammal prey.

Gun Hunting

Active hunting is now entirely reliant on guns that have replaced the earlier practice of hunting with bow and arrow. In the study village, a 67-year-old retired hunter appeared to have been the last practitioner of hunting with bow and arrow, a practice that he reported to have abandoned as recently as the year 2000. All the senior hunters reported that they hunted with bow and arrow until they acquired guns which started to become common in the early 1990's. Guns have been relatively common in Arunachal Pradesh and gun licenses can be easily procured as favours from politicians and the state government also issued gun licenses rather freely in the 1950's for protection of crops (Aiyadurai et al., 2010).[1] The ammunition cartridges used in these guns have become a common gift item among the men in the village and are sometimes also used as currency when dealing with a hunter. Hunters who have earlier hunted with bow and arrow stated the advantages of gun hunting, including the speed of the kill, the ability to shoot from far and the end of reliance on the rare *Aconitum* poison[2] (known as *yogmo* among the Adi) which was applied on the tips of the arrows. The disappearance of bow hunting has also seen various cultural aspects associated with it fade away. A village elder spoke about the *bango* festival[3] which was also associated with the preparation of the *yogmo* used for bow hunting. The process of making the poison had various taboos associated with it such as restrictions of washing any clothes or vessels during the process. These practices and taboos no longer exist and neither does the poison.

Hunting large mammals with guns occurs either in the form of drive hunts (*kiraw*) or by small groups or lone hunters. Drive hunts are commonly employed when the entire village or clan is hunting for an animal on the occasion of certain festivals. In this form of hunting, the eldest and most experienced member of the group is entrusted with

[1] There are reportedly 34,394 licenced gun holders in Arunachal Pradesh (Press Trust of India, 2017). In recent times, with easier access to shops and markets, ownership of guns has become common and most hunters possess a double barrelled or single barrelled shotgun.

[2] A genus of plants from the Ranunculaceae family and the genus Aconitum that grows in high altitude regions of the Northern hemisphere and is used to produce potent poisons used in hunting and warfare.

[3] Festival is primarily for the annual maintenance of the community hall or the *moshup*.

the gun and places himself at a strategic location. The other members of the group identify the tracks of a deer or a wild pig that is in the vicinity and drives that animal through shouting and loud noises towards the waiting hunter with the gun. Hunters are careful to note the topography and physical features in the region of the *kiraw* to minimise the chances of escape by the prey. The animal is forced into the path of the waiting gun where the designated hunter is able to make an easy kill.

Apart from the *kiraw* which involves the participation of a large number of people, small groups of hunters or even single hunters may go for hunts close to the village. Hunters usually identify trails or trees that are visited by deer or wild pig and look for signs of their movement. Having identified recent signs of their movement, the hunter waits quietly at some strategic location for the animal to pass through. Some hunters even construct small platforms (*chhang*) close to fruiting trees that are frequently visited by deer.

Hunting in small groups is usually done by a close group of hunters who are used to hunting with each other and are 'partners'. In most such cases, they will be accompanied by one or more hunting dogs. Hunting is based on detection and tracking of animal signs such as recent tracks or droppings. Although the hunt for the Takin does not take place in the vicinity of the village, hunters use the same strategy of identifying the Takin trails–looking for fresh signs of their presence and positioning themselves at locations where they have clear visibility of the animal.

Trapping

Trapping for large mammals is an important activity among hunters and is common during the drier winter months. Traps are deployed in areas that are located away from the village in old growth forest areas that are outside the swidden cultivation region that surround the village dwellings. Traps for large mammals are all snare traps (*pongit*) that are placed on animal trails and left for around a week (Fig. 2). Older hunters recollect using other varieties of traps such as hole traps in the ground which would be camouflaged with leaves. These traps no longer exist, and the only trap that is used regularly is the *pongit.* Earlier snare traps were made of cane and bamboo, while today with access to modern construction material, cable wires are used for traps. While traps for small mammals are still made from cane and bamboo, large mammal traps are all made from metal wires that are hardy and can be used multiple times. A variation on the *pongit* is the *badok*, a snare attached to a bent sapling, which when triggered by the movement of the animal pulls the snared animal upwards. The *badok* is relatively less common as it depends upon the availability of an appropriate sapling in the location where the trap is being planned.

Trapping near the village occurs in forest patches that belong to individual households or clans during the winter. While these individual trapping areas may provide some animals to the trappers, the most preferred trapping areas are located 1.5 days walk away from the village. These areas are not under individual ownership, but are communally owned. Four such locations are considered to be the best places for trapping large mammals because of their proximity to streams and salt licks. Serow, wild pig and barking deer visit these areas regularly, and trapping here provides good returns to hunters. These areas are provided to hunter groups every year on a first-come basis. The first group that approaches the *kebang* can 'reserve' the location by paying a token amount to them. Once a trapping location has been 'reserved' for that year, no other group can trap there. Failure to follow these rules attracts heavy fines from the *kebang.* An individual hunter can put up anything between 50 to 80 snares in one visit, placed along streams, animal trails and salt licks. The target species for these traps are wild pigs, Asiatic black bears, Himalayan serow, and barking deer. Hunters need to return once in every 10 days to check the traps to prevent the trapped animals from being scavenged by wild carnivores or from decaying. Some hunters may carry guns depending upon availability, and opportunistic hunting on the way or around the trapping areas may also occur. Trapping at other times of the year is rare as the weather and conditions in the forest are amenable only during the winter months.

Spatial Patterns of Large Mammal Hunting

Mapping Hunt Locations

Locational information was obtained in the form of local names commonly used by hunters and other people in the village. The entire area of the village has specific names which are used to designate different swidden areas, forests, fallows, mountains, streams, springs and other natural objects. These names are transferred orally across generations, and while no physical map existed, there was unanimity in the recognition of these areas and assigned names among the villagers. These detailed names are a traditional repository of orally transmitted knowledge and provide an accurate location of any activity (such as hunting) anywhere within the territory of the village. Local names were mapped onto the corresponding geographical locations based on field surveys and participatory mapping. This hybrid layer was overlaid on a base map of the area to plot locations of hunting and trapping incidents (Fig. 3).

Fig. 2 Snares, locally called *pongit* are most commonly used for trapping of animals

Distribution of Hunting in Relation to Village

A total of 95 prey animals were hunted during the observed period of 22 months by 28 different hunters. While gun hunting accounted for 45 of the animals, 50 were killed through snare traps.

Adi hunters have traditionally practiced hunting in areas adjoining the village as well as specific areas that are very far from the village. Hunts can be 'short-distance', 'medium distance' and 'long-distance' hunts based on the distance of the hunting areas from the village. The 'long-distance hunts' take place once a year in the winter months (December/January). These hunts are specifically undertaken to hunt the Takin. Another long-distance hunt is for hunting the Himalayan musk deer (*Moschus leucogaster*) which are also found far away from the village along the snow line near the Indo-China border. Musk deer hunts are rare and may happen only once in three years with very few hunters willing to go to these difficult areas. The results reported here include only the short and medium distance hunts conducted in village lands, while long-distance hunts of Takin and Himalayan musk deer conducted in non-contiguous hunting zones have not been considered.

Short distance hunts take place in the vicinity of the village and are completed within one day. These hunts occur exclusively within the zone of agriculture which includes current cultivation fields and fallows interspersed with patches of uncultivated steep forest land. Hunting does not occur in the few patches of terraced paddy fields within this zone since these are protected by fences, trenches and other barriers. All of these hunts took place between 0300 and 1930 h. Hunters prefer to leave early from their homes and

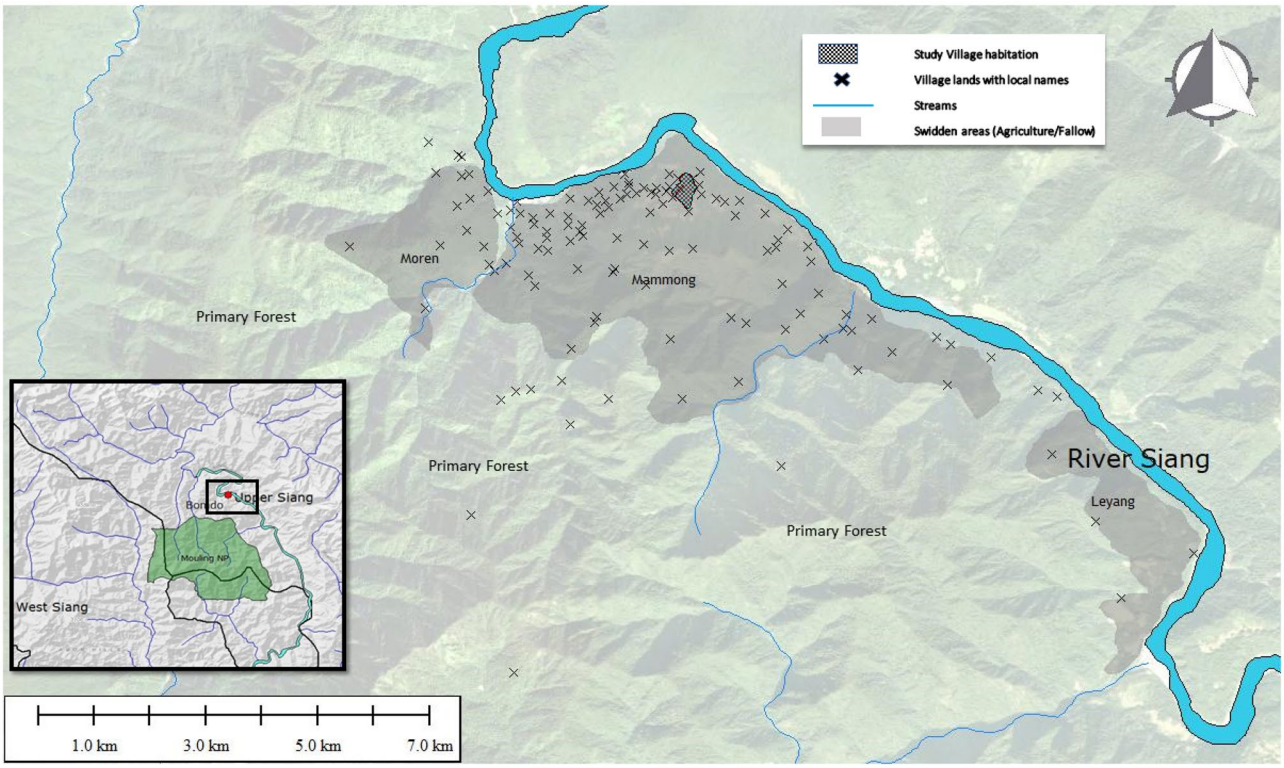

Fig. 3 Unique names are assigned to all areas within the village, including forest patches, streams and each parcel of swidden land, which are located inside blocks. These names were documented and placed on a map to understand spatial distribution of hunts from information provided by hunters

utilize the early morning and evening for hunts, as this is the time when animals are most active. The total number of hours spent on individual hunts was around 6 h, calculated as the number of hours spent by a hunter outside his house, including travel time as well as hunting time.

If we consider the spatial distribution of hunts/traps from the village, most of the hunts are concentrated between 2–4 kms from the village or more than 6 km from the village (Fig. 4). The distribution of hunts/traps across distance classes however is not evenly distributed. While most of the gun hunting occurs closer to the village, trapping as an activity mostly occurs far from the village at designated trapping areas.

The spatial distribution of the hunted species suggests that the swidden fallows (0–6 km from village) are dominated by resilient species like barking deer and wild pig. This is the area where 45% (n = 43) of hunts occurred and also accounted for most of the gun hunting.

The trapping through snares mostly occurs further away from the village (> 6 km) in four designated trapping areas located in old growth forest. These areas need to be 'reserved' by trappers beforehand and only one team of trappers is allowed per site. This reservation of trapping areas and monitoring of trapping activity is performed and monitored by the traditional village authority, the *kebang*. While most of the trapping (82%) occurs far away from the village, the majority of gun hunts (59%) occurs within 2–4 kms of the village. This is also the mixed-use landscape dominated by swidden fallows.

A map of the landscape with all the hunts demonstrate this clearly when overlaid with concentric circles of 2, 4 and 6 km's from the village. (Fig. 5).

In terms of biomass extracted by hunters, 56% of the biomass came from the agricultural zone around the village (Fig. 6). Hunting in the fallows is characterised by short hunting trips for species such as barking deer and wild pig which favour human modified landscapes. Wild pigs were the largest source of animal biomass (average of 74.5 kg) and male wild pigs provided the greatest biomass for a single individual. Barking deer (37.8%) and wild pig (38.9%) were the two most commonly hunted species.

Temporal Patterns of Hunting

The type of hunting is not the same throughout the year. Temporal hunting patterns appear to be influenced by the Adi agricultural calendar. Swidden cultivation season starts in the month of March and it is only after the harvest in the month of September/October that villagers are free of their agricultural responsibilities to spare more time for hunting and especially for trapping.

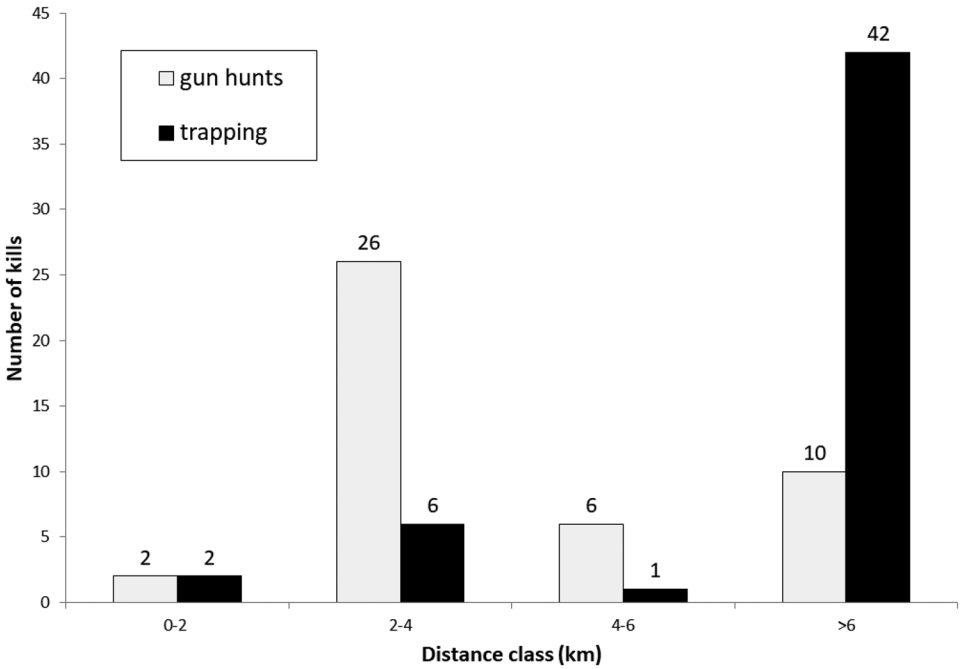

Fig. 4 Total number of hunts across distance classes to illustrate differences across landuse type. Swidden agriculture is found only within 6 km from the village but is an important area for hunters

An analysis of the spatio-temporal patterns of hunting indicates that 45% of large mammal hunts occur in the swidden fallows around the village while temporal intensity of hunting appears to be influenced by the timing of agricultural responsibilities among other things such as weather conditions (Fig. 7). The agricultural period is dominated by gun-hunting in the swidden fallows and secondary forests while trapping is largely absent, an observation that is supported by interviews where incidental hunts as a consequence of repeated movement through swidden areas have been mentioned.

Regulation By Local Institution

The *kebang* monitors the use of natural resources within the village and imposes fines if there are deviations from established rules. Complaints on the nature of declining resources can be brought to the attention of the *kebang* by any individual in the village and are then debated and analysed. In the event of adequate proof and support from other villagers, restrictions or modification of resource usage practices may be announced by the *kebang* council and are binding on all villagers. The closely knit nature of village societies and their interdependence on each other ensures compliance with the decisions of the *kebang*.

Rules on the conduct of hunting were found to be meticulously implemented by the *kebang*. The common hunting and fishing areas including the Takin hunting area (*bendhi*), the four common trapping areas for large mammals and also the communal fishing area are all managed by the *kebang*. In the case of the Takin hunt as well as for the communal trapping areas, hunters who wish to trap are required to pay a small fee to the *kebang* which is utilised for the welfare of the village. The allotment of prime trapping areas to limited number of people has ensured a limit on the extraction of animals. The trapping areas all have salt licks which make them desirable for animals like the serow, barking deer and even birds and rodents.

Safeguards with regard to over-extraction of fish was observed during the study period which was triggered by the drastic reduction in the number of fish during the communal fishing festival. The *kebang* stopped all forms of destructive and modern methods of fishing such as dynamite fishing, electric fishing and the use of nets. Enforcement included the confiscation of all nets and the announcement of massive fines against the use of dynamite and electrical charges.

Management and monitoring of resources also include looking for hunting or trapping by outsiders within the village areas. During the study period, there were four occasions when outsiders were caught and penalised for hunting within the village forests. While there is no formal system of patrolling, villagers routinely traverse the village territories to access bamboo, cane and other food resources apart from hunting. Regular movement of villagers as part of these activities allow them to notice anomalies in the landscape that may indicate the presence of outsiders.

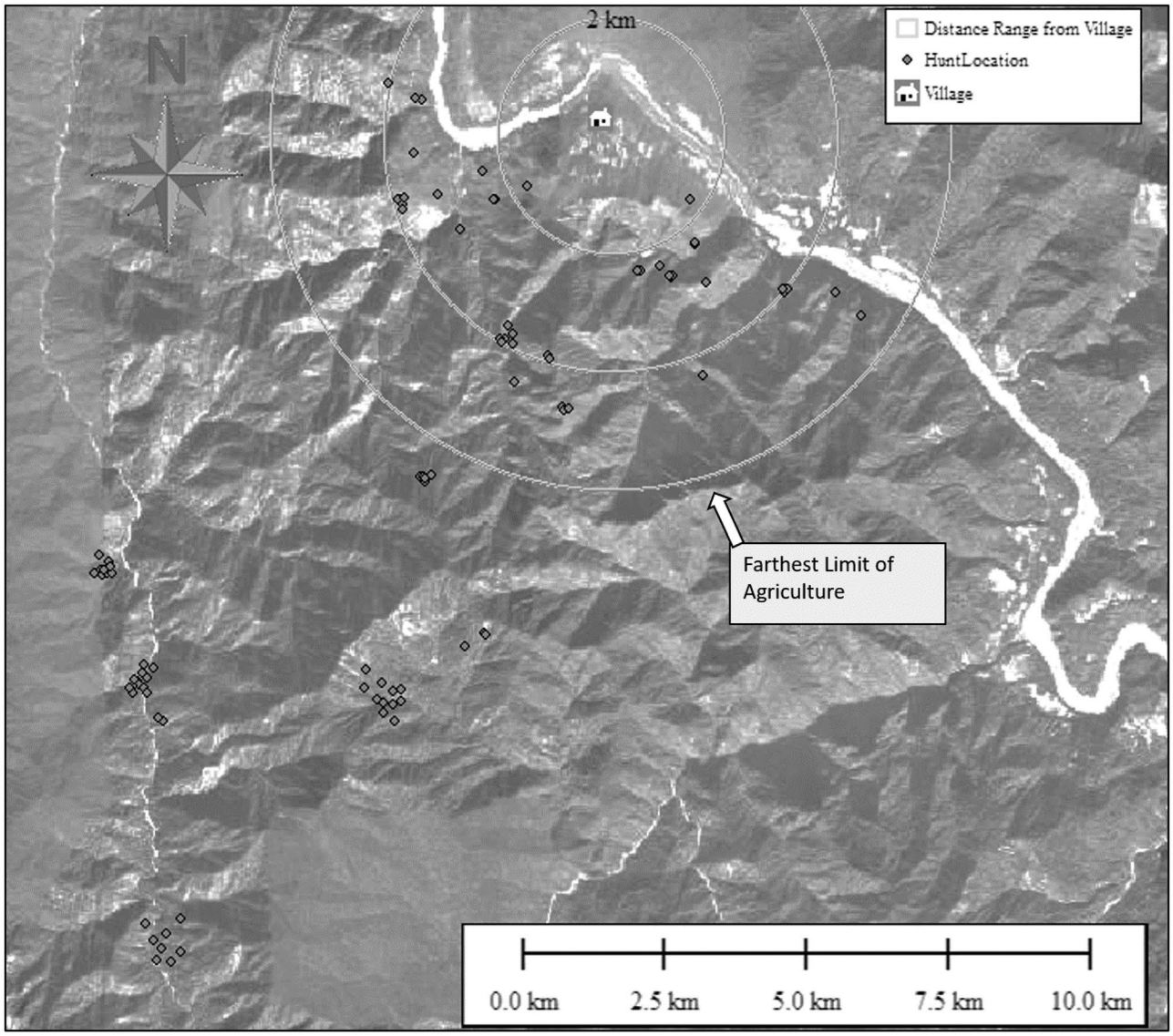

Fig. 5 Spatial representation of gun hunting and trapping on map shows seasonal trapping in specific locations clustered towards SW while 'garden hunting' occurs within the swidden fallow areas (within 6 km radius of the village)

Discussion

This study provides the first quantitative estimates of large mammal hunting in India to our knowledge and therefore does not have any existing studies to compare with in the region. Some studies in northeast India report the number of species that are hunted – 43 species (Chutia, 2010), 53 species of birds (Chutia & Solanki, 2013), 134 species (Hilaluddin et al., 2005), 33 species (Aiyadurai et al., 2010), 20 species (Velho & Laurance, 2013). These numbers include small and large mammals, birds, reptiles and even amphibians. However, these studies do not provide estimates of the number of individuals of each species that were hunted. The lack of quantitative information on hunting trends has been seen as a major drawback towards understanding the scale and pattern of hunting in the region. Without reliable quantitative estimates, statements implicating local hunting for extinction of species can hardly be considered legitimate.

Garden Hunting and Its Implications

Spatial patterns of large mammal hunting indicate the role of habitat around villages that are composed of a matrix of fallows, swidden fields and remnant forest patches. These areas are regularly visited by villagers to extract non-timber forest resources that provide food for themselves as well as domestic animals. These 'gardens' appear to be a particularly important source of large mammal prey for hunters.

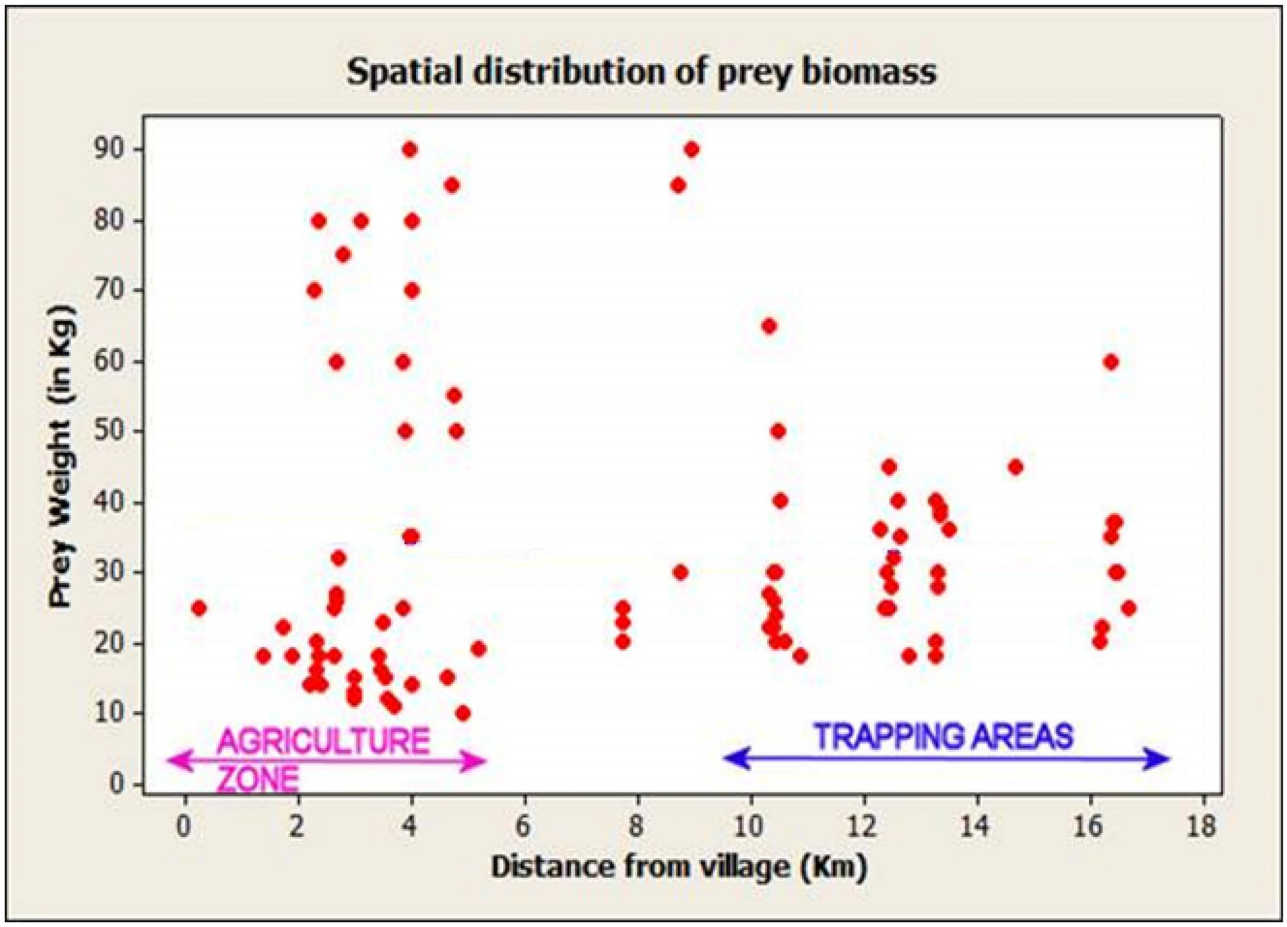

Fig. 6 Spatial distribution of hunted animal biomass indicates that almost half of hunted biomass is sourced within 6 km of village in the 'garden hunting' zone

'Garden hunting' is an umbrella term for hunting that occurs in cultivated fields and house gardens for primarily terrestrial animals that prefer such habitats (Linares, 1976). Evidence of early game animal procurement in human-modified horticultural 'gardens' by prehistoric hunters has been unearthed by environmental archaeologists while existing 'garden hunting' has been studied in the American tropics (Linares, 1976; Neusius, 2008). This form of hunting not only guarantees the availability of prey species in close proximity to the village, but also acts as a way to control crop predators.

In the context of swidden landscapes, garden hunting appears to be extremely important to hunters as shown by Smith (2010) in Panama, where almost half of all hunted animals were from agricultural fields and fallows. Similarly, Gavin (2007) found that in the Peruvian Amazon, while older forests are an important source of animal biomass for hunters, secondary forests provide more resources per unit area. The current study finds similar results with 45% of hunted animals accounting for 56% of total biomass being extracted from the secondary forest 'gardens' surrounding the village.

There has been no mention of garden hunting in the context of hunting in the swidden fallows of south and southeast Asia. These anthropogenic habitats are used extensively by animals such as the barking deer and the wild pig which are both considered 'anthropogenic fauna' that can withstand human presence and in fact thrive in such mixed use landscapes (Donkin, 1985; Naughton-Treves, 2002). This study indicates that these are also the same species which are hunted the most. These same species have in fact been demonstrated to be tolerant of anthropogenic landscapes in other studies from Arunachal Pradesh (2008). These results are consistent with observations by previous authors of 'garden hunting' among indigenous swidden cultivators in central and South America. Tolerance to anthropogenic landscapes by certain animals has been reported by other researchers even in the Amazon (Naughton-Treves et al., 2003; Parry et al., 2009). This has been attributed to their diet and behaviour – they are primarily opportunistic foragers tolerant of habitat disturbance and frequently found in secondary forests. This strongly suggests that the phenomenon of 'garden

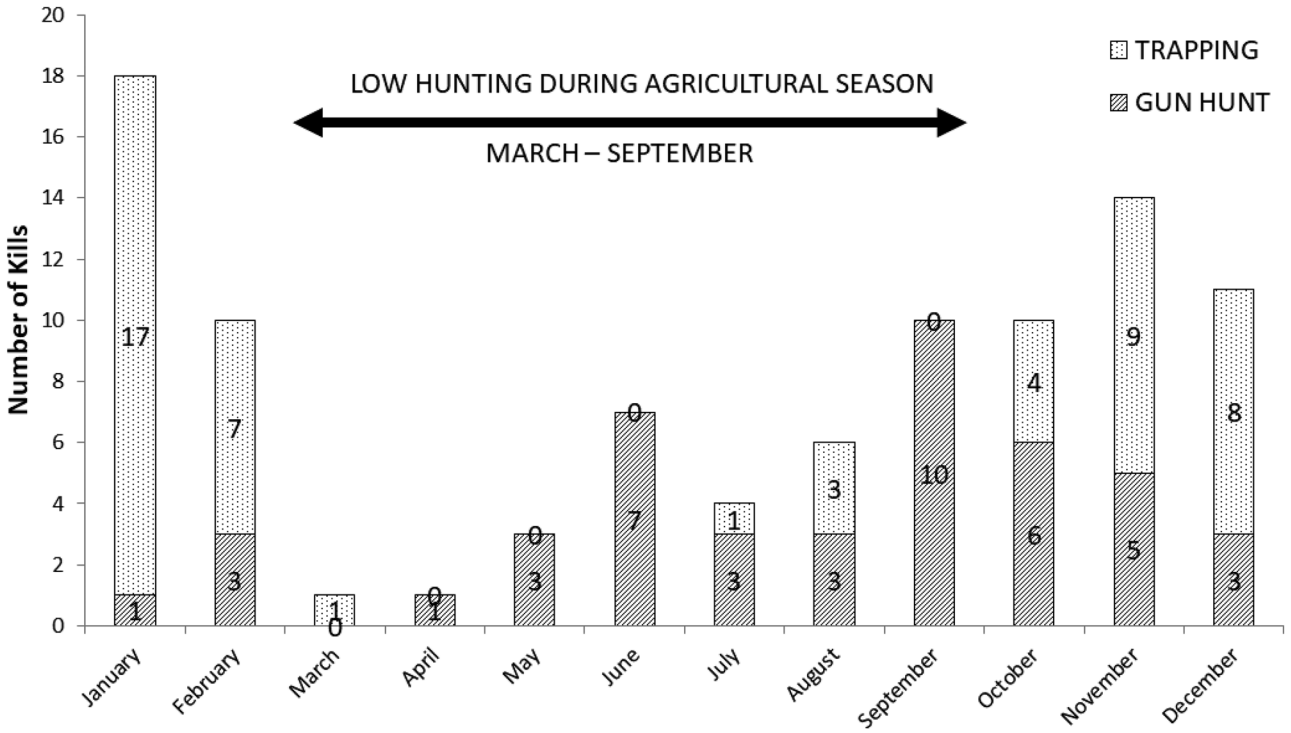

Fig. 7 Temporal distribution of all hunts through the year shows low hunting during the agricultural season and less trapping activity

hunting' has been prevalent among swidden fallows of Upper Siang.

Some studies have found evidence of active management by garden hunters to attract game animals (Dove, 1993; Greenberg, 1992; Posey, 1985) while others have not reported any such evidence of active manipulation (Linares, 1976; Naughton-Treves, 2002). This study also found no evidence of active habitat manipulation to attract prey among the Adi, although they are aware of the relation between human modified landscapes, regenerating fallows and the availability of game within these spaces. Existing literature on 'garden hunting' has discussed the importance of these areas for hunters in procuring mammals such as red brocket deer (*Mazama americana*), white-tailed deer (*Odocoileus virginianus*), collared peccaries (*Dicotyles tajacu*) and wild pigs (*Sus scrofa*). In the case of the Adi areas of Upper Siang, these 'gardens' are not just the source of large mammals, but they are also areas where trapping for small mammals and birds occur. These gardens, formed through the practice of swidden cultivation, play a central role in providing a constant source of prey animals allowing the Adi to use the undisturbed old-growth forest fauna sparingly.

Swidden Systems and Local Institutions

The growing prevalence of settled cultivation in the form of terrace farming and increase in commercial cropping signals agricultural transformation from the traditional swidden cultivation practices. These changing cultivation practices can impact hunter behaviour by depriving hunters of nearby hunting areas. The absence of mixed-use landscapes produced by swidden may shift hunting pressure to older forests farther away from the village. The presence of secondary forest 'gardens' and fallows thus hold high conservation significance.

The presence of game in gardens however, is not always a given and may depend on other local factors influenced by ecology, agricultural practices and cultural norms for the particular region. This may include anthropogenic factors like higher human population densities, connections with wild meat markets and integration with market forces (Robinson & Bennett, 2000a, 2000b) to ecological factors related to habitat heterogeneity. Spatial and temporal patterns of food availability, habitat structure and foraging behaviour are known to influence the characteristics of vertebrate communities in swidden landscapes and contribute to species richness and composition of vertebrate assemblages (Finegan & Nasi, 2004). Although anthropogenic species like wild pigs and barking deer may be attracted to swidden fallows, a 'source' population in adjacent forest areas that are not subjected to the same hunting pressure may be essential (Gavin, 2007).

In this study, contiguous 'source' areas comprise of the old growth forests belonging to the village community as well as the adjoining Mouling National Park which is controlled by the state. Hunting in the community managed

old-growth forests are strictly monitored and enforced by the traditional local institution of the *kebang* which plays an important role in controlling extraction levels. This includes controlling access to mineral lick areas visited by fauna regularly for geophagy and mineral rich water, making them 'hotspots' of diversity (Blake et al., 2011). Unrestricted access to areas of abundant faunal presence could result in over-extraction if not monitored continuously. Restrictions on the number of individuals who have access to these areas is an effective method to avoid such an eventuality, highlighting the role of local institutions like the *kebang* in effective management of common pool resources (CPR) that may contribute to conservation efforts (Dawson et al., 2021; Ostrom, 1990). Such effective management strategies and resultant 'balance' between indigenous people and nature are not necessarily evidence of conservation, but is important to their own long-term subsistence use.

Effectiveness of local institutions in checking hunting intensity in areas that are used by communities for faunal extraction is important in ensuring hunting sustainability in addition to the presence of gardens.

Acknowledgements I would like to acknowledge the support and friendship of the Adi community of Upper Siang without whom this study would not have been possible. I am deeply grateful to Nitin Rai and would like to acknowledge him for his constant support while his insightful comments and suggestions have helped guide my work at all stages.

Funding ATREE–NORAGRIC Small Grant. John D. and Catherine T. MacArthur Foundation through the Critical Ecosystem Partnership Fund program. The Rufford Foundation (Small Grant Program).

Data Availability Anonymized datasets generated during and analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Informed Consent Research was carried out in a remote village where I obtained informed consent at every step when speaking to hunters and respondents. I obtained only verbal consent due to low literacy levels. Initially I met with elders and leaders of local institutions to explain the nature of work and ask for permission to conduct the same. When speaking with individual respondents, I explained the objectives once again and informed them that participation was voluntary on their part. I also ensured that individual identification information was not used in the recorded data. The manuscript provides only location of the study village. At the end of the research period, I shared the information and findings with the village local institution and with various individual respondents to ensure that there was no misrepresentation.

Conflict of Interest The author declares no conflicts of interest.

References

Aiyadurai, A. (2011). "Wildlife Hunting and Conservation in North-east India: A Need for an Interdisciplinary Understanding." *International Journal of Galliformes Conservation* 2 (2): 61–73. http://www.academia.edu/download/31017582/Pages61-73_Aiyadurai.pdf.

Aiyadurai, A., Kent Ridge, N., Singh, J., Milner-Gulland, E. J. & Kent Ridge Correspondence. (2010). "Wildlife Hunting by Indigenous Tribes: A Case Study from Arunachal Pradesh, North-East India." *Oryx* 2 (August 2009): 1–9. https://doi.org/10.1017/S0030605309990937.

Alcorn, J. B. (1993). "Indigenous Peoples and Conservation." *Conservation Biology* 7 (2): 424–26. https://pdfs.semanticscholar.org/b2b0/6c64098dd598b1bdb9a5552f9aece7c5837f.pdf.

Antunes, A. P., Rebêlo, G. H., Pezzuti, J. C. B., Regina, M. A., de Mattos Vieira, Pedro de Araujo Lima Constantino, João Vitor Campos-Silva, Rogério Fonseca, et al. (2019). A Conspiracy of Silence: Subsistence Hunting Rights in the Brazilian Amazon. *Land Use Policy, 84*(March), 1–11. https://doi.org/10.1016/j.landusepol.2019.02.045

Bennett, E. L., Eves, H. E., Robinson, J. G., & Wilkie, D. S. (2002). Why Is Eating Bushmeat a Biodiversity Crisis. *Conservation Biology in Practice, 3*, 28–29.

Bhupathy, S., Kumar, S. R., Thirumalainathan, P., Paramanandham, J., & Lemba, C. (2013). Wildlife exploitation: A market survey in Nagaland. *North-Eastern India. Tropical Conservation Science, 6*(2), 241–253.

Blake, J. G., Mosquera, D., Guerra, J., Loiselle, B. A., Romo, D., & Swing, K. (2011). Mineral Licks as Diversity Hotspots in Lowland Forest of Eastern Ecuador. *Diversity, 3*(2), 217–234. https://doi.org/10.3390/d3020217

Blue Marble Geographics. (2013). Global Mapper Version 15.

Chutia, P. (2010). Studies on Hunting and the Conservation of Wildlife Species in Arunachal Pradesh. *Sibcoltejo, 05*, 56–67.

Chutia, P., & Solanki, G. S. (2013). Patterns of Bird Hunting in Arunachal Pradesh and Implications for Biodiversity Conservation. *Tropical Ecology, 54*(2), 263–267.

Constantino, P. D. L., Fortini, L. B., Kaxinawa, F. R. S., Kaxinawa, A. M., Kaxinawa, E. S., Kaxinawa, A. P., Kaxinawa, L. S., Kaxinawa, J. M., & Kaxinawa, J. P. (2008). Indigenous Collaborative Research for Wildlife Management in Amazonia: The Case of the Kaxinawa, Acre, Brazil. *Biological Conservation, 141*(11), 2718–2729. https://doi.org/10.1016/j.biocon.2008.08.008

Datta-Roy, A. (2018). "Hunter Identity in a Changing Landscape." *Seminar*, no. February: 41–45.

Datta-Roy, A., Vivek, R., & Karthik, T. (2018). "An Annotated Checklist of the Birds of the Upper Siang Region, Arunachal Pradesh, India." *Journal of Threatened Taxa* 10 (5): 11636. https://doi.org/10.11609/jott.3784.10.5.11636-11651.

Datta, A. (2002). "Status of Hornbills and Hunting Among Tribal Communities in Eastern Arunachal Pradesh."

Datta, A. (2007). "Threatened Forests, Forgotten People." In *Making Conservation Work*.

Datta, A., Anand, M. O., & Naniwadekar, R. (2008). "Empty Forests : Large Carnivore and Prey Abundance in Namdapha National Park , North-East India" 1. https://doi.org/10.1016/j.biocon.2008.02.022.

Dawson, N., Coolsaet, B., Sterling, E., Loveridge, R., Nicole, D., Wongbusarakum, S., Sangha, K., Scherl, L., Phan, H.P., Zafra-Calvo, N. & Lavey, W. (2021). The role of Indigenous peoples and local communities in effective and equitable conservation. *Ecology and Society*, *26*(3).

Dirzo, R., & Miranda, A. (1991). "Altered Patterns of Herbivory and Diversity in the Forest Understory: A Case Study of the Possible Consequences of Contemporary Defaunation." *Plant-Animal Interactions: Evolutionary Ecology in Tropical and Temperate Regions. Wiley, New York*, 273–287.

Dirzo, R., Young, H. S., Galetti, M., Ceballos, G., Isaac, N. J. B., & Collen, B. (2014). Defaunation in the Anthropocene. *Science, 345*(6195), 401–406. https://doi.org/10.1126/science.1251817

Dollo, M., Gopi, G. V. G. V. G. V., Teegalapalli, K., & Mazumdar, K. (2010). Conservation of the Orange-Bellied Himalayan Squirrel Dremomys Lokriah Using a Traditional Knowledge System: A Case Study from Arunachal Pradesh, India. *Oryx, 44*(04), 573–576. https://doi.org/10.1017/S0030605310000785

Donkin, R. A. (1985). The Peccary: With Observations on the Introduction of Pigs to the New World. *Transactions of the American Philosophical Society, 75*, 1–152. https://doi.org/10.2307/1006340

Dove, M. R. (1993). "The Responses of Dayak and Bearded Pig to Mast-Fruiting in Kalimantan: An Analysis of Nature-Culture Analogies." *MAN AND THE BIOSPHERE SERIES* 13: 113–113. http://cpasru.nl/node/10657.

Dudley, N., Higgins-Zogib, L., & Mansourian, S. (2009). The Links between Protected Areas, Faiths, and Sacred Natural Sites. *Conservation Biology, 23*(3), 568–577. https://doi.org/10.1111/j.1523-1739.2009.01201.x

Dunn, M. A., & Smith, D. A. (2011). "The Spatial Patterns of Miskitu Hunting in Northeastern Honduras : Lessons for Wildlife Management in Tropical Forests." *Journal of Latin American Geography* 10 (1).

Elwin, V. (1960). *A Philosophy for NEFA*. S. Roy on behalf of the North-East Frontier Agency.

Estes, J. A., Terborgh, J., Brashares, J. S., Power, M. E., Berger, J., Bond, W. J., Carpenter, S. R., et al. (2011). Trophic Downgrading of Planet Earth. *Science*. https://doi.org/10.1126/science.1205106

Fa, J. E., Olivero, J., Farfán, M. Á., Márquez, A. L., Vargas, J. M., Real, R., & Nasi, R. (2014). Integrating Sustainable Hunting in Biodiversity Protection in Central Africa: Hot Spots, Weak Spots, and Strong Spots. *PLoS ONE, 9*(11), e112367. https://doi.org/10.1371/journal.pone.0112367

Finegan, B., & Nasi, R. (2004). "The Biodiversity and Conservation Potential of Shifting Cultivation Landscapes." In *Agroforestry and Biodiversity Conservation in Tropical Landscapes*, 153–97.

Gavin, M. (2007). Foraging in the Fallows: Hunting Patterns across a Successional Continuum in the Peruvian Amazon. *Biological Conservation, 4*(1), 64–72. https://doi.org/10.1016/j.biocon.2006.07.011

Gorenflo, L. J., Romaine, S., Mittermeier, R. A., & Walker-Painemilla, K. (2012). Co-Occurrence of Linguistic and Biological Diversity in Biodiversity Hotspots and High Biodiversity Wilderness Areas. *Proceedings of the National Academy of Sciences, 109*(21), 8032–8037. https://doi.org/10.1073/pnas.1117511109

Greenberg, L. S. Z. (1992). Garden Hunting among the Yucatec Maya: A Coevolutionary History of Wildlife and Culture. *Etnoecológica, 1*(1), 23–33.

Hames, R., & Raymond, H. (2007). The Ecologically Noble Savage Debate. *Annual Review of Anthropology, 36*(1), 177–190. https://doi.org/10.1146/annurev.anthro.35.081705.123321

Haridasan, K., Borang, A., & Pratap, S. (1999). "Baseline Survey of Biodiversity in High Priority Biologically Rich Areas of Arunachal Pradesh." New Delhi.

Hilaluddin, R. K., & Dipankar, G. (2005). "Conservation Implications of Wild Animal Biomass Extractions in Northeast India." *Animal Biodiversity and Conservation* 28 (2): 169–79. https://www.raco.cat/index.php/abc/article/view/56770.

Hill, K., & Padwe, J. (2000). "Sustainability of Aché Hunting in the Mbaracayu Reserve, Paraguay." *Hunting for Sustainability in Tropical Forests*, 79–105. http://www.meatradio.com/uploads/pdf/Hill and Padwe - Sustainability of Hunting.pdf.

Hilton-Taylor, C., & Stuart, S. N. (2009). "Wildlife in a Changing World." Edited by Jean-Christophe Vié, Craig Hilton-Taylor, and Simon N. Stuart. https://doi.org/10.2305/IUCN.CH.2009.17.en.

Katti, K. V., Manrekar, N., Mukherjee, S., & Sharma, D. (1990). "A Report on Wildlife Survey in Arunachal Pradesh with Special Reference to Takin." *Unpublished Report to the Wildlife Institute of India*.

Kumar, R. S., Nabam Gama, R., Raghunath, A. S., & Mishra, C. (2008). In Search of the Munzala: Distribution and Conservation Status of the Newly-Discovered Arunachal Macaque Macaca Munzala. *Oryx, 42*(03), 360–366. https://doi.org/10.1017/S0030605308006121

Kumara, H. N., & Singh, M. (2004). The Influence of Differing Hunting Practices on the Relative Abundance of Mammals in Two Rainforest Areas of the Western Ghats, India. *Oryx*. https://doi.org/10.1017/S0030605304000560

Linares, O. (1976). 'Garden Hunting' in the American Tropics. *Human Ecology, 4*(4), 331–349. https://doi.org/10.1007/BF01557917

Madhusudan, M. D., & Karanth, K. U. (2002). "Local Hunting and the Conservation of Large Mammals in India." *Ambio* 31 (1): 49–54. http://www.ncbi.nlm.nih.gov/pubmed/11928358.

Mena, V. P., Stallings, J. R., Regalado, J. B., & Cueva, R. L. (2000). "The Sustainability of Current Hunting Practices by the Huaorani." *Hunting for Sustainability in Tropical Forests*, 57–78.

Milner-Gulland, E. (2003). Wild Meat: The Bigger Picture. *Trends in Ecology & Evolution, 18*(7), 351–357. https://doi.org/10.1016/S0169-5347(03)00123-X

Myers, N., & R a Mittermeier, C G Mittermeier, G a da Fonseca, and J Kent. (2000). Biodiversity Hotspots for Conservation Priorities. *Nature, 403*(6772), 853–858. https://doi.org/10.1038/35002501

Naoroji, R., & Sangha, H. S. (2006). Arunachal Pradesh, India : An Ornithological Diary from December 2005. *Indian Birds, 2*(5), 120–131.

Naranjo, E. J., & Bodmer, R. E. (2007). Source-Sink Systems and Conservation of Hunted Ungulates in the Lacandon Forest, Mexico. *Biological Conservation, 138*(3–4), 412–420.

Naughton-Treves, L. (2002). Wild Animals in the Garden: Conserving Wildlife in Amazonian Agroecosystems. *Annals of the Association of American Geographers, 92*(3), 488–506. https://doi.org/10.1111/1467-8306.00301

Naughton-Treves, L., Mena, J. L., Treves, A., Alvarez, N., & Radeloff, V. C. (2003). Wildlife Survival Beyond Park Boundaries: The Impact of Slash-and-Burn Agriculture and Hunting on Mammals in Tambopata, Peru. *Conservation Biology, 17*(4), 1106–1117. https://doi.org/10.1046/j.1523-1739.2003.02045.x

Neusius, S. W. (2008). "Game Procurement among Temperate Horticulturists The Case for Garden Hunting by the Dolores Anasazi." In *Case Studies in Environmental Archaeology*, 297–314. New York, NY: Springer New York. https://doi.org/10.1007/978-0-387-71303-8_15.

Newton, P. N. (2002). "Bird Records from the Siang River Valley, Arunachal Pradesh, India." *Forktail* 18 (January 2000): 156–57.

Nichols, E., Gardner, T. A., Peres, C. A., & Spector, S. (2009). Co-Declining Mammals and Dung Beetles: An Impending Ecological Cascade. *Oikos, 118*(4), 481–487.

Nielsen, M. R., Henrik M., Carsten S. -H., Marième P., & Thorsten, T. (2018). "The Importance of Wild Meat in the Global South." *Ecological Economics* 146 (March 2017): 696–705. https://doi.org/10.1016/j.ecolecon.2017.12.018.

Nijhawan, S., & Mihu, A. (2020). Relations of Blood: Hunting Taboos and Wildlife Conservation in the Idu Mishmi of Northeast India. *Journal of Ethnobiology, 40*(2), 149. https://doi.org/10.2993/0278-0771-40.2.149

Ostrom, E. (1990) Governing the Commons: The Evolution of Institutions for Collective Action Cambridge University Press 0521405998).

Parry, L., Barlow, J., & Carlos a Peres. (2009). Hunting for Sustainability in Tropical Secondary Forests. *Conservation Biology, 23*(5), 1270–1280. https://doi.org/10.1111/j.1523-1739.2009.01224.x

Pawar, S. S., & Birand, A. (2001). "A Survey of Amphibians, Reptiles, and Birds in Northeast India." *CERC Technical Report # 6*.

Peres, C. A., & Nascimento, H. S. (2006). Impact of Game Hunting by the Kayapo of South-Eastern Amazonia: Implications for Wildlife

Conservation in Tropical Forest Indigenous Reserves. *Biodiversity and Conservation, 15*(8), 2627–2653.

Peres, C. A., Gardner, T. A., Barlow, J., Zuanon, J., Michalski, F., Lees, A. C., Vieira, I. C. G., Moreira, F. M. S., & Feeley, K. J. (2010). Biodiversity Conservation in Human-Modified Amazonian Forest Landscapes. *Biological Conservation, 143*(10), 2314–2327. https://doi.org/10.1016/j.biocon.2010.01.021

Poffenberger, M. (2006). "Forest Sector Review of Northeast India." http://mdoner.gov.in/writereaddata/sublink3images/19.pdf.

Posey, D. A. (1985). Indigenous Management of Tropical Forest Ecosystems: The Case of the Kayapo Indians of the Brazilian Amazon. *Agroforestry Systems, 3*, 139–158. https://doi.org/10.1007/BF00122640

Press Trust of India. (2017). "UP Comes First in Active Gun Licences." *The Hindu*, October 2, 2017. http://www.thehindu.com/news/national/up-comes-first-in-active-gun-licences/article19786617.ece.

Quantum GIS Development Team. (2015). Quantum GIS Geographic Information System. Open Source Geospatial Foundation Project.

Read, J. M., Fragoso, J. M. V., Silvius, K. M., Luzar, J., Overman, H., Cummings, A., Giery, S. T., & Flamarion de Oliveira, L. (2010). Space, Place, and Hunting Patterns among Indigenous Peoples of the Guyanese Rupununi Region. *Journal of Latin American Geography, 9*(3), 213–243. https://doi.org/10.1353/lag.2010.0030

Robinson, J., & Bennett, E. L. (2000a). "Carrying Capacity Limits to Sustainable Hunting in Tropical Forests." Hunting for Sustainability in Tropical Forests, 13–30.

Robinson, J. G., & Bennett, E. L. (2000b). Carrying Capacity Limits to Sustainable Hunting in Tropical Forests. *In Hunting for Sustainability in Tropical Forests13-30*. https://doi.org/10.1016/S0169-5347(00)02081-4

Roldán, A. I., & Simonetti, J. A. (2001). Plant-Mammal Interactions in Tropical Bolivian Forests with Different Hunting Pressures. *Conservation Biology, 15*(3), 617–623.

Schwartzman, S., & Zimmerman, B. (2005). Conservation Alliances with Indigenous Peoples of the Amazon Conservation Biology.https://doi.org/10.1111/j.1523-1739.2005.00695.x

Singh, S., Singh, T. P., & Srivastava, G. (2005). Vegetation Cover Type Mapping in Mouling National Park in Arunachal Pradesh, Eastern Himalayas- an Integrated Geospatial Approach. *Journal of the Indian Society of Remote Sensing, 33*(4), 547–563. https://doi.org/10.1007/BF02990740

Smith, D. A. (2008). The Spatial Patterns of Indigenous Wildlife Use in Western Panama: Implications for Conservation Management. *Biological Conservation, 141*(4), 925–937. https://doi.org/10.1016/j.biocon.2007.12.021

Smith, D. A. (2010). Garden Game : Shifting Cultivation, Indigenous Hunting and Wildlife Ecology in Western Panama. *Human Ecology, 33*(4), 505–537. https://doi.org/10.1007/s10745-005-5157-Y

Smith, E. A., & Wishnie, M. (2000). Conservation and Subsistence in Small-Scale Societies. *Annual Review of Anthropology, 29*(1), 493–524. https://doi.org/10.1146/annurev.anthro.29.1.493

Tamang, L., Chaudhry, S., & Choudhury, D. (2006). On a New Record of Freshwater Fish, Pseudolaguvia Shawi (Hora) from Arunachal Pradesh, India (Teleostomi : Erethistidae). *Zoos' Print Journal, 21*(May), 2443–2446.

Teegalapalli, K., & A, Datta,. (2016). Shifting to settled cultivation: Changing practices among the Adis in Central Arunachal Pradesh, north-east India. *Ambio, 45*(5), 602–612. https://doi.org/10.1007/s13280-016-0765-x

Velho, N., & Laurance, W. F. (2013). Hunting Practices of an Indo-Tibetan Buddhist Tribe in Arunachal Pradesh, North-East India. *Oryx, 47*(3), 389–392. https://doi.org/10.1017/S0030605313000252

Vliet, N. van., André, P. A., Pedro de A. L. C., Juanita G., Dídac, S.-F., & Eugenio, S. (2019). "Frameworks Regulating Hunting for Meat in Tropical Countries Leave the Sector in the Limbo." *Frontiers in Ecology and Evolution* 7 (AUG). https://doi.org/10.3389/fevo.2019.00280.

Wilkie, D. S., & Carpenter, J. F. (1999). Bushmeat Hunting in the Congo Basin: An Assessment of Impacts and Options for Mitigation. *Biodiversity and Conservation, 8*(7), 927–955. https://doi.org/10.1023/A:1008877309871

Wilkie, D. S., Bennett, E. L., & Carlos a Peres, and Andrew a Cunningham. (2011). The Empty Forest Revisited. *Annals of the New York Academy of Sciences, 1223*(March), 120–128. https://doi.org/10.1111/j.1749-6632.2010.05908.x