Comparing Historical Tibetan Population Estimates with the Monks and Nuns: What was the Clerical Proportion?

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A. Introduction

This study estimates Tibet's historical population-based on potential farmland and grain yields to determine what the proportions of monks and nuns were according to a list of clerics residing in the Buddhist monasteries of U-Tsang (i.e., Central Tibet) during the Ganden Podrang period of the eighteenth through mid-twentieth centuries. A particular focus of this study is the construction of a spatial model of the clerical proportion of Tibetan society during recent centuries before the large-scale destruction of this traditional socioeconomic system after China's incorporation of Tibet into the new Peoples' Republic during the 1950s. Before this time, the occupational structure of Tibet's economy included a large proportion of Buddhist monks and nuns. Faced with the dearth of historical monastic census data, scholars have only guessed what these clerical proportions of the Tibetan population were. These 'educated guesses' tend to focus exclusively on the monks, ranging from about 10 to 25 percent of the male population (Goldstein 2010; Jansen 2018). This study finds monks comprised about 18 percent of the male population or about 9 percent of the total Central Tibetan population, while nuns comprised about 6 percent of the female population or close to 3 percent of the total population, which is more significant than previous studies indicate (Table 1). Furthermore, these clerical patterns exhibited unique geographic characteristics, with more males drawn to the large teaching centers in core regions such as Lhasa and Shigatse, leaving female nuns to actually outnumber monks in some peripheral regions.

Data on the numbers of Tibetan monasteries, and the monks and nuns resident at each site, were compiled into a spreadsheet from historical archives in Lhasa by the late Tibetan scholar Tsering Gyalpo

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(1961-2015) who gave me a copy. Based at the Tibetan Academy of Social Sciences (TASS) in Lhasa, Gyalpo served as director of its Religious Studies Department from 1995 up to his untimely passing in Berlin (Hazod 2015). He adopted the prefix Guge denoting a historical name for his home region in Western Tibet; hence some of his works are attributed to Guge Tsering Gyalpo as the author. This list of the monks and nuns will be described in detail in the data section below, but suffice it to say here that 81,998 monks are listed in 1,413 monasteries arranged by the *Dzong* (Tib. rdzong; i.e., forts or districts, hereafter dzong) of Central Tibet under the jurisdiction of the Lhasa-based Ganden Podrang government (Map 1). Also, 6,525 nuns are listed in 326 monasteries for a part of this region. No data are provided for monasteries in the eight forts and estates of Tsang supervised by the Panchen Lamas of Tashilhunpo monastery until 1923, which indicates these figures pertain to some period before then. Also, no data are provided for areas of religious estates of particularly elite status, namely Sakya in Tsang and the valleys of Thurphu (of the Karmapas) and Drigung in U (i.e., the eastern part of Central Tibet). And the districts of Phari and Dromo (Chin. Yadong) are also excluded from this study because the data is incomplete for these areas.

In contrast to detailed historical records of the numbers of monasteries and clerics, there did not seem to be similar needs by indigenous Tibetan bureaucracies for the collection and recording of demographic data for the overall Tibetan population. The well-known Mongol Census of Tibet from the thirteenth century merely estimated the number of households in thirteen local divisions of Central Tibet, but the data is not accurate enough to reconstruct key demographic indicators from, such as for fertility and growth rates, let alone the numbers of monks. And, surviving archival demographic data from Tibet is too small scale, only covering the persons connected with particular local estates such as servants and tenant farmers, thus preventing any accurate historical reconstruction of the overall Tibetan demographic situation (Childs 2000). Mention should also be made of the often-cited history of the Gelukpa sect (Dga' ldan chos 'byung; "History of Ganden") by the Fifth Dalai Lama's Regent Sanggye Gyatso (1653-1705), which includes lists of the more important monasteries (from this sectarian point of view) as well as the numbers of monks resident at each site. But being a partial listing for only one sect, these data are not sufficient for providing an accurate model of the historical clerical proportions of the Tibetan population.

Table 1: Ratios of Monks and Nuns ca. 18th and 19th Centuries by Dzong.

Dzong	*Model Pop.*	*1990 Pop.*	*Change*	*Monks*	*Nuns*	*Monk Ratio*	*Nun Ratio*
Total/Mean%	**1,208,255**	**1,311,144**	**144%**	**82,106**	**6,525**	**9%**	**3%**
Lhasa	42,833	265,044	619%	19,315	117	45%	-
Lhundrub	15,323	18,679	122%	4,750	-	31%	-
Lhagyari	6,685	23,255	348%	1,983	45	30%	1%
Gyamda	3,994	17,295	433%	1,121	-	28%	-
Gongkar	11,593	24,800	214%	3,042	1,410	26%	12%
Chokhorgyal	7,009	5,166	74%	1,559	601	22%	9%
Kunam	2,595	11,558	445%	450	478	17%	18%
Dzongka	8,977	11,178	125%	1,522	-	17%	-
Drigu	5,557	6,988	126%	934	107	17%	2%
Olkha	4,468	8,460	189%	689	215	15%	5%
Zadam	11,406	28,926	254%	1,740	-	15%	-
Chushur	16,270	27,932	172%	2,453	-	15%	-
Tagtse	18,039	18,575	103%	2,540	-	14%	-
Tsona	5,933	6,645	112%	826	-	14%	-
Shigatse	57,269	66,601	116%	7,365	-	13%	-
Gyatso	1,889	9,606	508%	241	-	13%	-
Khartse	5,091	4,008	79%	620	-	12%	-
Chongye	23,377	27,712	119%	2,264	-	10%	-
On	13,679	10,272	75%	1,250	35	9%	-
Rinpung	13,227	20,183	153%	1,174	-	9%	-
Kyirong	5,156	3,408	66%	448	-	9%	-
Lhuntse	28,046	26,335	94%	2,333	1,033	8%	4%
Zhokha	5,712	8,505	149%	476	107	8%	2%
Nedong	36,456	33,534	92%	2,575	386	7%	1%
Lingkar	5,029	10,705	213%	345	-	7%	-
Lhabu	4,174	7,861	188%	275	-	7%	-
Tsegang	25,825	16,231	63%	1,686	402	7%	2%
Nakhartse	31,402	20,048	64%	1,772	-	6%	-
Samye	19,680	16,489	84%	1,058	-	5%	-
Tingkye	18,746	7,569	40%	937	-	5%	-
Gyangtse	98,729	59,913	61%	4,539	-	5%	-
Malgung	34,914	37,022	106%	1,601	-	5%	-
Namling	28,520	19,408	68%	1,220	-	4%	-
Dowa	19,057	10,851	57%	560	480	3%	3%
Darma	11,735	7,885	67%	316	509	3%	4%
Langtang	8,407	11,919	142%	225	-	3%	-
Dol	29,813	34,896	117%	749	-	3%	-
Jomo	10,708	21,608	202%	259	272	2%	3%
Panam	48,313	39,017	81%	1,106	-	2%	-
Nyemo	29,803	32,367	109%	683	-	2%	-
Kyimtong	6,577	13,509	205%	142	223	2%	3%
Lhakhang	5,213	2,534	49%	107	51	2%	1%
Senge	7,153	3,620	51%	147	54	2%	1%
Nyanang	11,388	5,853	51%	229	-	2%	-
Phari	6,996	13,064	187%	-	-	-	-
Shelkar	162,813	42,412	26%	2,372	-	2%	-
Ciblung	39,749	14,603	37%	-	-	-	-
Gampa	18,680	8,417	45%	-	-	-	-
Rinchentse	20,536	23,485	114%	-	-	-	-
Sakya	29,653	11,018	37%	-	-	-	-
Lhunrab	31,856	25,245	79%	-	-	-	-
Lhatse	27,388	22,618	83%	-	-	-	-
Puntsokling	9,239	24,847	269%	-	-	-	-
Shetongmon	26,750	24,267	91%	-	-	-	-
Tanak Rinchetse	17,077	13,050	76%	-	-	-	-
Ngamring	11,746	24,148	206%	-	-	-	-

B. Defining Tibetan Economy and Monasticism

Given the unique historical situation in Tibet that supported large numbers of non-agricultural occupations at monasteries, it can be argued that the larger monasteries also be considered urban centers even though they do not fit traditional Eurasian models of cities (Ryavec 2020). The sparse resources of the Tibetan Plateau did not permit as

many urban centers to develop as in lowland cultures. But the larger Tibetan monasteries filled the same role as the city in lowland agrarian societies in providing centers of political authority, safe places for markets, and storage for products and livestock, and thus functioned in an urban-like role in the traditional economic system. In particular, these resource-based limitations may help to explain how and why the Tibetan clergy grew to such a significant proportion of the population and provided the labor for a great many occupations. For example, according to Cabazon and Dorjee (2019), the large monastery of Sera on the outskirts of Lhasa housed according to tradition approximately 5,500 monks (listed with 5000 monks in this dataset). This number rose to 9,224 by 1959, but only about 25 percent of the monks of the philosophical colleges (which comprised most of the monks) were actively studying. The rest were involved in various other occupations concerning the administration of the monastery, such as cooking and overseeing agricultural estates that provided grain and other products.

These occupational categories should be more clearly articulated and not lumped together into a generic monk or nun category if we are to better understand Tibet's economic history and how it was able to support a larger proportion of its population in educational institutions without and prior to industrialization, unlike other human societies. Not only were there numerous religious specializations such as chant leader, meditation master, oracle, and so forth, but monks also worked as doctors, astrologists, grain keepers, painters, and so forth. But numerous academic arguments positing that Tibet's traditional economy functioned as a Medieval feudal serf-based system until its demise during the 1950s, such as by Goldstein (1998) and Ma (1998), create major obstacles to better understanding historical Tibetan socioeconomic systems in comparative historical perspective. These arguments, however, do not hold-up in comparison with Medieval European economies, where religious occupations merely comprised about 1.6 percent of the total population, or no more than 3 percent of the male population (Russel 1944). Also, usury was not prohibited in Tibet, and the monasteries earned profits on their loans, unlike the proscriptions against usury in Medieval Christian societies. Furthermore, to define Tibet's economy by the modern period ca. 1500-1950 as Medieval would need to assume that Tibet was some sort of "living fossil" in a land where time stood still, clearly an absurd idea not worthy of serious consideration. Instead, many aspects of the Modern Capitalistic World System constructed around the Columbian Exchange affected Tibetan society and economy, too, such as the introduction of the important New World crops of potato and maize and their contributions to population growth and the circulation of New World silver. For example, in Goldstein's (1971 a) study of taxation in a Tibetan village in

Central Tibet during the Ganden Podrang period, several tax-in-kind items (such as leather rope and grain) listed in early documents had actually been converted to payment in silver coinage by the nineteenth century if not earlier.

Despite the great differences between Tibetan and European economic systems historically, what could be termed "The Mobility Fallacy", articulated in an early influential study by Goldstein (1971 b) about restrictions on movement in Central Tibetan society, gave supporters of the Feudal School of Tibetan economic history one of their main lines of argument. According to this view, however, the contemporary Chinese economy would also be defined as a feudal serf-based system because most peoples' movements are similarly restricted by state actors. Tibetans now require official permission to travel both internally (such as within Central Tibet or between Amdo and Central Tibet), and internationally which is extremely curtailed by the confiscations of passports (mostly since 2008) and refusals to issue new ones in most cases.

C. Explanation of Terms

There are numerous works in the Tibetan Studies field that define in great detail what Buddhist monasteries and nunneries were and who qualified as a monk or nun. Jansen's (2018) recent study of Buddhist monastic organization in pre-modern Tibet based on monastic guidelines or *chayik*, for example, adequately covers these topics. This present study instead breaks new ground by focusing on all the monasteries of Central Tibet instead of individual case studies as has been the norm up to now. These monasteries ranged from small single shrine caves and buildings with just one resident cleric to massive multi-structure complexes with numerous shrines, assembly halls, and dormitories housing thousands of monks studying in specific colleges. Even the Bonpo religious establishments of Tibet, while adhering to a non-Buddhist religion, could still be considered monasteries within the purview of this study because the Bonpo actively sought enlightenment and generally followed a Buddhist-like curriculum. However, the data on monks and nuns utilized in this study does not include any Bonpo monasteries because they do not cover areas in Tsang where some Bonpo monasteries still existed in Central Tibet by the Ganden Podrang period. These areas may have been under the jurisdiction of Tashilhunpo monastery in Shigatse or relatively independent, but they were not covered in the districts administered from Lhasa.

D. The Tibetan Census of Monks and Nuns

The numbers of monks or nuns listed for each monastery were entered into a spreadsheet format by Tsering Gyalpo from his handwritten entries in notebooks based on historical archival sources according to 48 dzong in Central Tibet under the administration of the Lhasa-based Ganden Podrang government ca. 1642-1959. Data for monasteries with nuns, however, are only included for 18 dzong in a largely contiguous region of U. Phari dzong was excluded because only two monasteries are listed, while no data is included for Dromo to the south in the Chumbi Valley. It is also important to note that data for Tsona dzong includes monasteries to the south in the Tawang Tract now administered by the Indian state of Arunachal Pradesh.

There are many secular handwritten government documents that only survive in closed archives in Tibet and China that offer invaluable information about Tibetan social and economic history. This dearth of historical records dilemma partly explains why the Tibetan studies field is largely focused on Buddhist studies because religious texts were often mass-produced, mainly by wood-block printing, to meet the needs of large numbers of adherents and are thus relatively easier to access, while government tax and related records only required one or several hand-written documents for the needs of the small largely noble run state bureaucracy. It is likely these figures on the monasteries in each dzong and the numbers of clerics would have been recorded for the administrative needs of each dzongpon (i.e., governor), such as for promoting religious observances and offerings to various deities, as well as ensuring the physical needs of the monks and nuns were provided for considering the raison d'être of the Ganden Podrang government was to ensure as many people as possible could attain enlightenment.

The spatial coverage of these clerical numbers is complex due to the way the data are arranged. Some districts are combined under a single heading, such as that for Shigatse and Rinchentse, though both district areas are approximated in our spatial analysis for greater accuracy in estimating historical farmland, population, and clerical proportion. While the opposite situation applies to the districts of Nedong and Sreng Dzong – E Khul represented with one combined district area. It was not clear where this dzong was located, but the area of coverage southeast of Nedong is clear due to some well-known monasteries listed, such as the destroyed large Gelukpa monastery of Riwo Choling that once housed 221 monks, and the still surviving famous Yumbu Lhakhang (Yam bu glang mkar) listed as a Nyingma establishment with eight monks.

Data are also provided for monasteries in parts of Ngari (western Tibet) and Kham (eastern Tibet) that were also administered by Ganden Podrang, but these data are not included in this present study. These excluded data for parts of Kham are listed under Nagchu, Lhari, and the combined headings of Khyung po khul - Khams khul (which also includes data for Powo), while for parts of Ngari, the data are listed under Ngari Korsum. It is hoped to analyze the historical clerical proportions of the populations in these regions and compare them to Central Tibet in future studies.

This Excel spreadsheet has been placed in a Dataverse for all students and scholars to freely access, given how important these data are in providing the most accurate historical listing of the monasteries and numbers of monks and nuns in Tibet (https://doi.org/10.7910/DVN/DUGC7Z). Except for a field titled Dzong and listing a Romanized phonetic transcription of each Dzong or district for ease in viewing and sorting, the spreadsheet file is original and complete as Tsering Gyalpo created it.

The first field in the file is titled Sa gnas (place name) and lists the Tibetan name of 51 dzong or estates. The second field is titled Dgon pa' mtshan (monastery name) and lists the names of 1739 monasteries. The third field is titled Chos lugs (religious method) and lists the sectarian affiliation of each monastery. Tibetans use the term luk (Lugs), which may be roughly translated as "method," as in a specific method or way to achieve enlightenment for the English concept of sect or denomination. In addition to the four main sects (since Bon sites are not included) of the Nyingma, Sakya, Kagyu, and Gelukpa, some minor traditions are listed, and some establishments are listed as teaching various combinations of traditions. Specifically, there are 406 Nyingma, 204 Sakya, 386 Kagyu, and 636 Gelukpa monasteries. Also, 55 Chod (i.e. severance tradition), 13 Bodong, 4 Ras (i.e. cotton; denoting the ascetic white cotton-clad followers of Milarepa), and 1 Jonang sites are listed. An additional 31 monasteries are listed as establishments that practiced both Nyingma and Gelukpa traditions, and two that practiced Nyingma, Sakya, and Gelukpa traditions. Of course, the actual historical situation was more complex than this simple listing. For example, in Medrogungkar dzong (i.e., Malgung in Gyalpo's file) east of Lhasa there was a Sakya college, listed as a Sakya sectarian establishment named Gyama Dratsang with 62 monks, attached to the large Gelukpa monastery of Rinchengang with 110 monks. But this site is not listed as a combined Sakya-Gelukpa monastery; instead, each site is listed separately in this dzong, and the fact that they were located in the same overall complex was ascertained from talking with a former monk.

The fourth field is titled Gra ba' grangs 'bor (number of monks), and the fifth field btsun ma' grangs' bor (number of nuns). The final syllable, 'bor, is the one used in the term population (mi 'bor); when turned into a verb means "to enumerate," as in a census. Thus, the term may imply the monks and nuns were actually enumerated once (Geoff Childs personal communication). Again, it is regrettable that Tsering Gyalpo did not leave a detailed record of which archival document(s) he consulted in compiling these data before his untimely passing. It is possible he did or confided in someone who may later hopefully elucidate more. But it was clear from official collaborative research projects with him and the Tibetan Academy of Social Sciences in Lhasa during the 1990s and early 2000s that Gyalpo was consulting historical archival data closed to foreigners, and while internal Chinese workers are generally not permitted by the government to copy or photograph such materials on their own, there are often allowed to take notes. And this appears to be what happened, someone re-wrote down these five key variables of place, name, sect, and numbers of monks and nuns, thus providing the most accurate and complete listing of these data ever available for contemporary academic research.

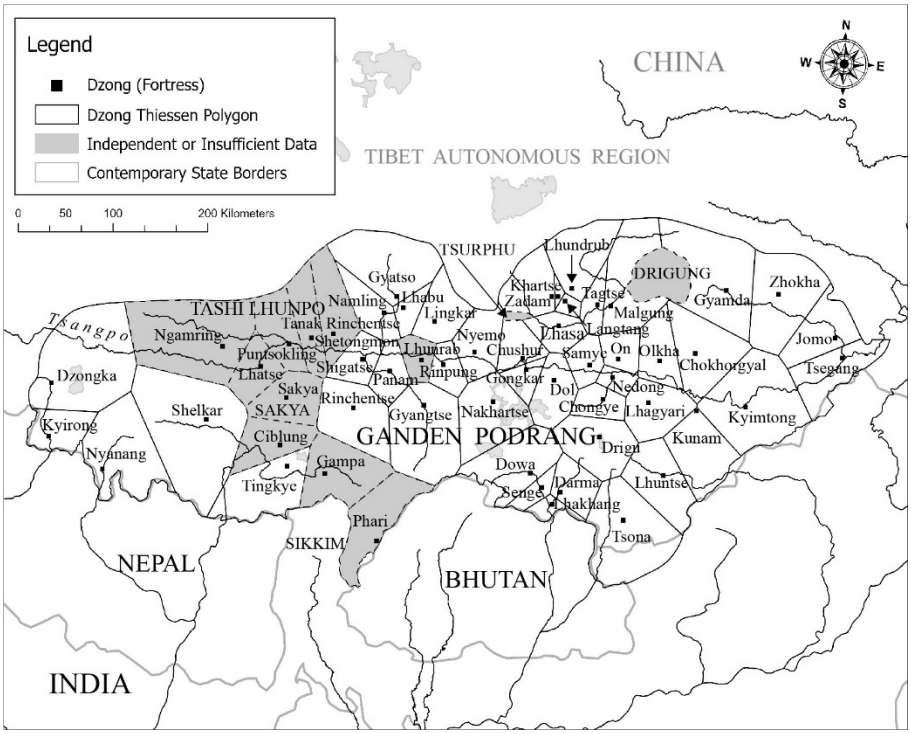
E. Methods

Arriving at a population estimate to compare the clerical population found in the census required preprocessing the census data, modeling potential farmland, and conducting various calculations relating to grain yields and calorie intake. The researchers preprocessed data and performed most geospatial operations via Python 3.8 scripts in or out of QGIS 3.10. Geospatial modeling was performed within the QGIS interface.

Preparing census data

Several organizational operations were necessary to prepare the tabular census data for a join to available spatial data. The census contains nearly 2000 entries of localities where a monastery or nunnery existed and its respective count of clergy members. While the dzong is specified, no individual marker denotes where each monastery was within its area. Directly mapping each monastery is currently impossible without detailed and complete gazetteers or maps that currently do not exist. Instead, each central Tibetan dzong's known fortress locations within the study area helped demarcate rough, sub-regional areas. Thiessen polygons, or spatial shapes representing the area to each

point relative to all other points, were generated to stand in for undefined census areas (Map 1). Although aggregation is not ideal when more nuanced data is present, the scheme used adheres to how the data was initially collected or summarized even at the dzong level and is still more disaggregated than anything at present. Thus, the tabular data was primarily kept in its original form, yielding a sum of clerics. This data was then joined to the Thiessen polygons by matching dzong.



Map 1: The study area in Central Tibet ca. 1642-1923, exhibiting dzong point distribution and Thiessen polygon coverage. Grey polygons indicate a lack of data or political affiliations outside the scope of the study.

Modeling farmland

Modeling potential arable land that existed across the study area was crucial to estimating adequate population data. Regional information for arable land exists for the study area, but any data set has its drawbacks. The Food and Agriculture Organization of the United Nations (FAO) created the Global Land Cover data set using satellite-derived

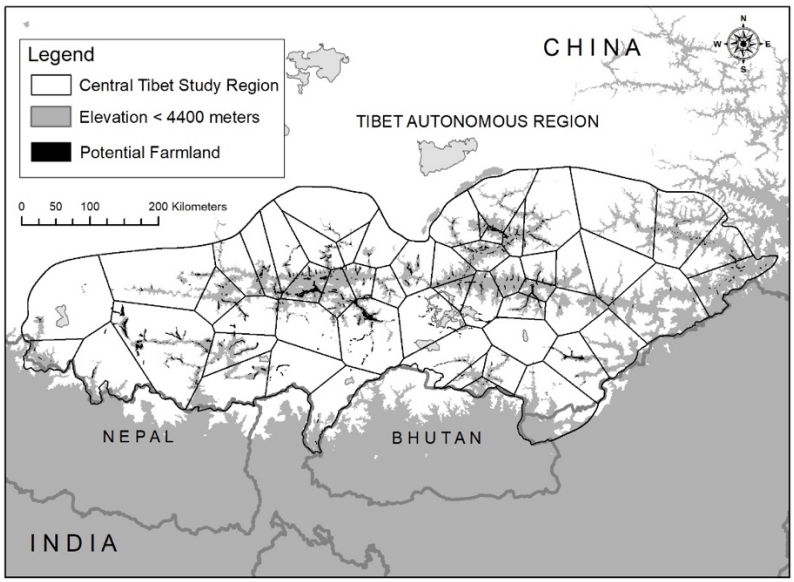
data and algorithmic derivation. While convenient and useful, the researchers found that this data set often failed to detect farmland, especially in Himalayan areas where arable land is patchy in narrow river valleys. In addition, the one-kilometer resolution is coarse and often overestimates how much farmland is present as spatial markers are quite large.

Human-digitized data also exists. Farmland in Central Tibet was digitized from the *1:1,000,000 Land-use Map of China* (Wu 1990). These data conform more to the contours of valleys and rivers. At the outset, these data were useful in establishing a spatial distribution and providing an expectation that most farmland occurred along the broad valley of the Tsangpo River. Closer inspection using modern satellite imagery reveals there are some discrepancies, especially in the region around Shelkar. However, either more or less farmland existed historically than exists today after several decades of significant change. For this reason, we rely primarily on these data. The researchers also supplemented these data with hand-digitized coverage based on satellite imagery to fill in where potential historical farmland was missing around Nakhartse and the southeast in general.

Some assumptions are made to simplify a regional model within which variability exists at different scales. First, satellite imagery captures contemporary and not historical land use. Given that demographics, total population, and agricultural techniques have changed since historical periods, modeling based on modern imagery is likely to inflate the amount of cultivated land, though to what extent is difficult to predict. Thus we focus on "potential" cultivated land rather than any "actual" known land use. Besides, precisely how much land was cultivated as barley is unknown. Estimates going back to 1953 assume barley made up around 70% of cultivated land and was the largest source of calories (Laurent 2015; Tashi, Yawei, and Xingquan 2013; Ma 1995). Certainly, as a staple crop, it helped people the Plateau since the Neolithic (Witze 2014). Millet, and most recently winter wheat, are also cultivated, though barley contains more calories per grain (Bates, Petrie, and Singh 2018) and has a longer history. Therefore, we reduced the total area of our modeled farmland by 70% to reflect diversified cultivation strategies. However, our estimates are still anchored in the cultivation of barley which remains a necessary component. Given the historical importance and persistence of barley cultivation on the Plateau and thermal niches that have endured for many centuries (d'Alpoim Guedes, Manning, and Bocinsky 2016), even modern imagery reveals much of the distribution of arable land, which is comparable to recent history.

Elevation constraints

Elevation, especially in high-altitude environments like the Tibetan Plateau, sets hard limits on what can be cultivated and where. The FAO's Global Land Cover dataset indicates that a vast majority (up to 99%) of barley cultivation occurs below 4000 meters above sea level. However, our sample suggests that the FAO dataset misses some farmland up to 4200 meters in western and south-western parts of the Plateau as well as the area around Lake Yamdrok Yumtso up to 4500 meters. A great majority of the arable land exists under 4400 meters with a few exceptions, and this became our upper limit.



Map 2: Distribution of digitized, potential farmland in relation to elevation under 4400 meters above sea level. While much of the model remains within the 4400-meter limit, some farmland is still found above this limit in special niches, especially in the center of the study area.

Quantifying grain yields

The amount of barely that could be reasonably cultivated and harvested from each hectare of potential farmland is an important variable for the estimation of carrying capacity and established a foundation for further calculations. Today, barley fields can produce from five to six

tons of barley per hectare (Tashi, Yawei, and Xingquan 2013). Historically, before the use of chemical fertilizers, this figure was around 1.5 to 2.2 tons per hectare without fallowing, according to Henry Osmaston (Osmaston 1995). The latter estimate is preferred as it reflects traditional agricultural yields. Even so, how yields varied over space and time are unknown and likely depended on local differences in climate, resources, and knowledge. Both 1.5 and 2.2 tons per hectare were entered as parameters in the calculation, with an average taken at the end under the assumption that most yields achieved some value within this range.

Counting calories

A final parameter to estimate carrying capacity is caloric intake or, more generally, energy need related to barley harvests. Not only did people need barley to eat but also to store for the following year's seed, pay taxes, and conduct rituals. Similar to spatially estimating potential farmland over a large area, estimating caloric intake is multiplicative and can significantly affect model output. Studies estimating population tend to rely on FAO, WHO, or other national health organization recommendations for caloric intake—roughly 2000 calories for women and 2500 calories for men—but we believe this is more appropriate for modern, urbanite populations and less than what historical, predominately subsistence farmers would have needed. For example, grain rations in both ancient Mesopotamia and Egypt provided roughly 3000 calories per person on average, assuming one kilogram of barley provides around 3,600 calories (Ellison 1981; Miller 1991).

Based on fieldwork, Henry Osmaston estimated that the average person required 225kg of barley per year for basic subsistence, which amounts to around 74% of our model caloric requirements (assuming 3600 calories per kg) but around 89% of the total intake for a man and up to 111% of a woman's intake if using contemporary measures of caloric needs. While barley-based meals were very common in traditional Tibet, where Tsampa (barley flour) was the staple food, an entire diet comprised of barley is unsustainable from a nutritional standpoint. Additionally, after the beginning of direct Chinese control, barley and other grain rations for workers were considered very low by Tibetans at around 218 kg per year (2150 calories per day if used exclusively for food) in Lhasa during the 1960s through the 1970s and around 181 kg in Dingri (1,785 calories per day if used exclusively for food) on the Tibet-Nepalese border (Rumbold 1980). If 2,150 calories per day were considered low, then a 3000-calorie budget is not unreasonable in a high altitude, relatively cold environment. Therefore, we use Osmaston's estimate of grain consumption, rounding up to 75% of

an individual's daily calories. Besides direct consumption, planting and animal fodder consumed an additional 92kg of barley. In sum, the model assumes 320 kg of barley needed per person, per year.

Estimating Population

The output of the proposed model is a sum of each Thiessen polygon's population calculated using the aforementioned parameters. Farmland coverage is aggregated within each polygon, provided area calculations in hectares which are then multiplied by high (2.2) and low (1.5) grain yields and caloric value then divided by the energy needed from barley. The result is a total population value for the respective polygon.

Stated formally for all 56 Thiessen polygons, for total population P, let A be areas in hectares of potential farmland observed for a polygon i in the series multiplied by 70% to reflect barley's share of cultivation. Let Y represent grain yield in tons, and C represent the number of calories provided by one ton of barley. Under the division line, let F be barley needed as food multiplied by D or share of an individual's diet. Finally, let O be other uses of barley not related to immediate consumption but still necessary.

$$P = \sum_{i=1}^{56} \frac{((A_i * 0.7) * Y * C)}{(F * D) + O}$$

F. Results

Carrying Capacity Potential and Population Yields

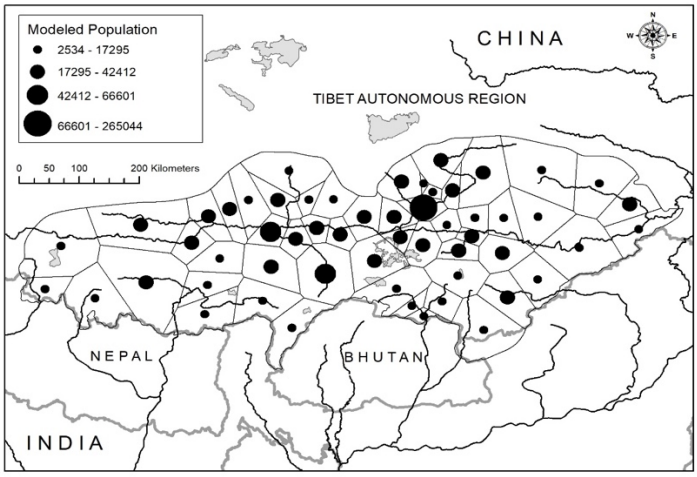
The maximum potential yields of barley grain given the range between 1.5 and 2.2 tons per cultivated hectare are 979,667 and 1,436,844 people, respectively, with a mean Central Tibetan population of 1,208,255 (Table 1). The modeled total population average falls below the total population found in China's 1990 census of 1,311,144. Specifically, the Central Tibetan population increased 144 percent by 1990. This particular census was utilized for two reasons: 1) Sub-county township-level data are available, allowing comparisons with historical dzong areas. 2) The total figures largely reflect the settled farming population before China's relaxation of internal immigration controls by the increase in massive economic growth and social change starting in the 1990s. Also, security concerns excluded the inclusion of Chinese immigrants already in Tibet by 1990, especially large numbers of police and military

personnel. Therefore, the historical, modeled population sits comfortably as a maximum potential for the 18th and 19th centuries. Again, this is a maximum potential without considering other variables such as trade—though there was likely no significant bulk trade in grain—mortality, births, and other demographic factors. Long-distance trade across Tibet historically was based on items not locally available and thus of greater value, such as tea from China and salt from dry lake beds distant from most farming communities. Historical records do indicate a small amount of rice was imported from India and Nepal as a luxury, not a staple item for some wealthy elites, while long-distance trade in large amounts of barley would not have been profitable given its weight and local availability. However, the smaller, wholly nomadic populations in high altitude pockets of Central Tibet and especially on the Changtang to the north relied on Tsampa as a staple food item. So in the Changtang case, some small amount of ground barley was exported each year from the core Central Tibetan farming region, but we do not know how much. Additionally, the modeled estimate becomes less accurate the further one moves back in time as available labor shrinks.

Spatializing results generally confirm the population distribution historically and currently, with a majority of the population clustered in the ecoregions of U, centered around Lhasa, and Tsang, centered around Shigatse (Map 3). Himalaya-adjacent and more rugged ecoregions (Himalayan and Lhoka) in the eastern and southern sections of the study area contain less arable land and thus a lower carrying capacity. Yamdrok Yumtso is not as large as other ecoregions but makes for a unique catchment in the center of the study area, exhibiting a carrying capacity of about 30,000 people despite almost all of the area being above 4400 meters. The model produced a greater population here than what is found in the 1990 census. Drigu, a predominant pastoralist district, received the least population and gained only a nominal amount of population between the model and the 1990 census. The regions of U and Dokpo/Kongpo also gained population between the model and 1990, while other regions were modeled with higher populations, especially in the Himalayan region.

Map 3: Modeled populations for each ecoregion in the study area. U and Tsang are expectedly the cores of population density.

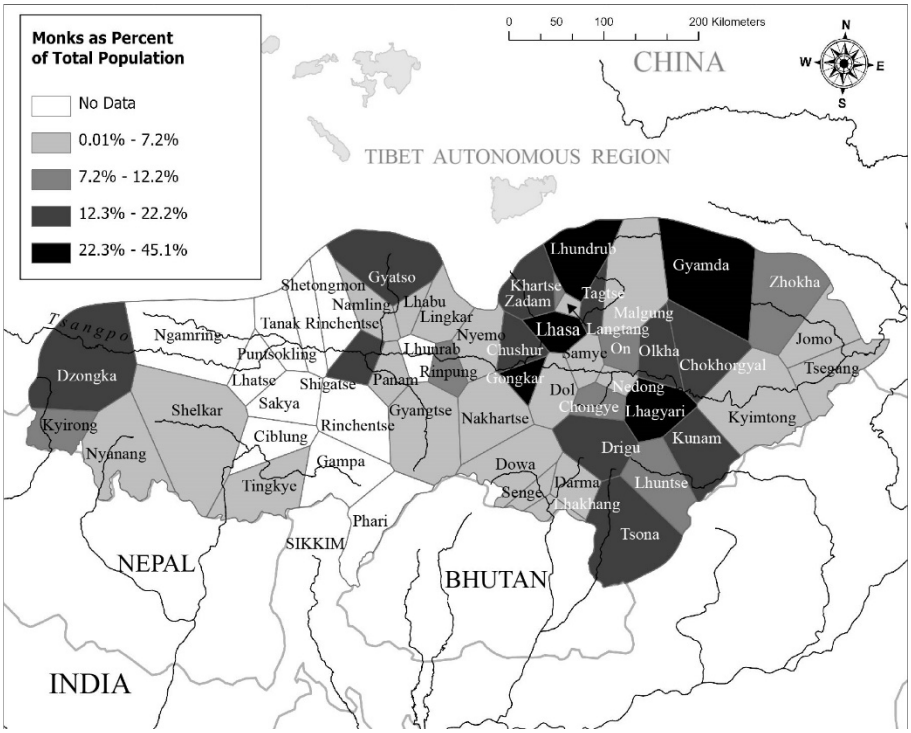
When the historical estimated population data are visualized at the dzong level, those districts in the U and Tsang regions hold much of the population of the entire area (Map 4). One seeming outlier is Shelkar in the southwest, which receives a large amount of potential farmland from available coverage and thus a high population estimate. However, the polygon for this dzong is the largest and thus captures a large modeled estimate.



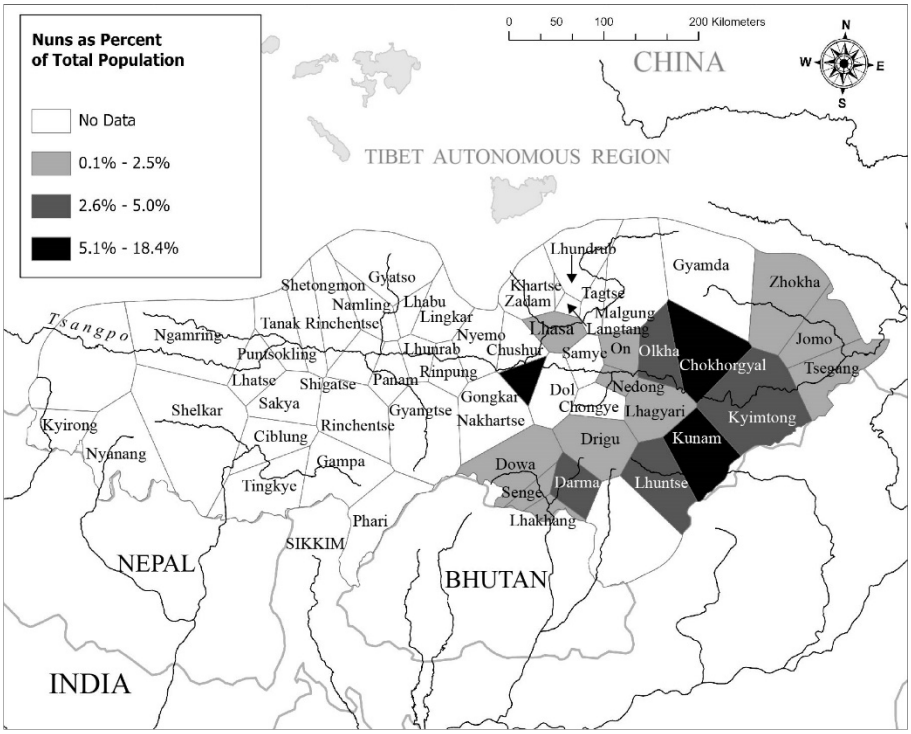
Map 4: Population estimates for each dzong.

How Large was the Clerical Proportion?

Results of the model indicate that, at the time of the census, clerics may have constituted a significant proportion of the total Central Tibetan population. A total of 88,523 clerics are listed in the census. In relation to the modeled population, clerics constitute about 12% of the total population. However, spatial disaggregation reveals that this mean ratio hides significant geographic variability. When investigating the monk proportions, sub-regional areas exhibited a range of estimates from 2% - 7% to as high as 45% of the entire population for the central district of Lhasa where of course many monks came to study from other parts of Tibet such as Amdo and from other countries such as Mongolia (Map 5). Findings on the nun proportions, as mentioned above, are limited to data available for 18 dzong in the southeast (Map 6).



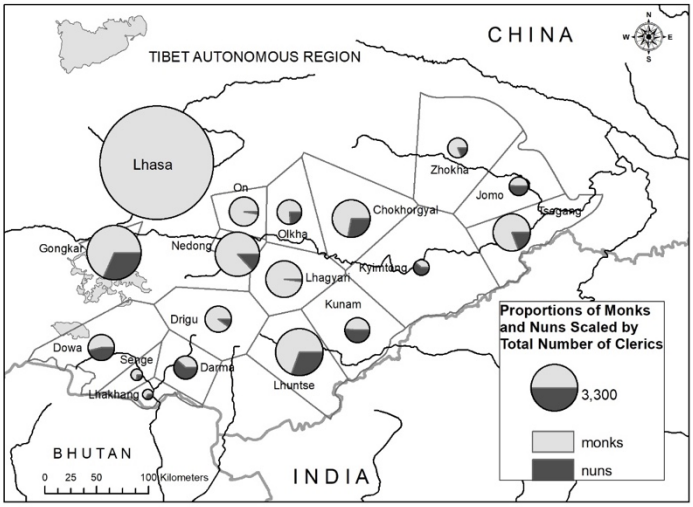
Map 5: Ratios of male monks to historical modeled population estimate.



Map 6: Ratios of female nuns to historical modeled population estimate.

These ratios of monks and nuns reveal significant geographic variation. Where population levels are higher, in and around Lhasa and Shigatse, the ratio of monks is relatively high, above 10 percent of the population. Surprising results include Dzongka in the far west, which has 1522 monks compared to its total population of 6100, indicating monks comprised about a quarter of the population. Drigu exhibits a high monk ratio due to its very low carrying capacity. However, the model is based on barley cultivation, and therefore the pastoral economy is not captured here. It is also important to understand if a few larger monasteries in an area did more to increase local monk and nun ratios than numerous small monasteries and hermitages; however, it is still impossible to locate each of the 1413 monasteries documented for most of Central Tibet, so this important question still remains unanswered. Four monasteries housed over 1000 monks, namely the Three Seats (Sera with 5000, Drepung with 6000, and Ganden with 2800), as well as Taklung monastery in Lhundrub dzong with 3340 monks. And, 185 monasteries housed over 100 monks each, or about ten percent of the total sites.

A particularly important finding of this study shows that nuns actually outnumbered monks in four peripheral dzong along the Himalaya; in Darma, Jomo, Kunam, and Kyimtong (Map 7). This situation has not been noted or discussed in the Tibetan studies field to date and is potentially of groundbreaking significance, and while more historical records and research is required to fully ascertain this phenomenon, it does seem plausible considering how many boys were drawn to the larger teaching monasteries in core areas such as Lhasa, especially when they already had an uncle or older brother there to sponsor them. Girls, however, were far less likely to have this option in becoming a nun and likely needed to find a nunnery closer to home and these local sites tended to be smaller. There were far fewer large nunneries in these 18 dzong of Central Tibet than monasteries, but where some larger nunneries existed there were, of course, correspondingly larger ratios of nuns. Though only four nunneries housed over 100 nuns each. The largest was Moling (Mo gling), a Drukpa Kagyu convent in Gongkar dzong with 215 nuns. To the east in Nedong dzong the convent of Sheldrakpa (Shal brag pa), a Nyingma establishment, housed 117 nuns. And further east in Chokhorgyal two Geluk establishments also housed relatively large numbers, one with 124 nuns (Sger dga' ldan dgon), and one with 106 nuns (Bkra shis gling).



Map 7: Comparable ratios of monks and nuns in the 18 dzong with available nun figures. Interestingly, in the four peripheral dzong of Darma, Jomo, Kunam, and Kyimtong nuns outnumbered monks.

Limitations

The model presented here was designed to add geographic variability and test the widely assumed monk ratio being one-quarter of the male population. Unfortunately, accurate and precise reconstructions of Tibet's population and economy during the historical period are lacking, let alone in useable data sets. Farmland was generalized here using modified, available data but does not reflect all types and distributions of crops that existed pre-1950. Also, backcasting potential populations is always subject to ignoring historical trends and large events. Still, without detailed demographic data, other attempts to estimate population, especially for more remote areas, are equally fraught with data problems.

G. Discussion

Tibet stands as a unique case of social complexity and stratification in world history. Throughout much of its history, Tibet supported a large clerical class dedicated to education and enlightenment without colonial extraction. Qualitatively, what Marx called the "primitive accumulation" of capital through the exploitation of the "lower classes" occurred in Tibet as it did in Europe; however, something underlying these politico-religious systems created a divergence. Whereas Feudalism and Manorialism perhaps could have, but did not, allow a significant proportion of Europe's population to move from agricultural work into academic pursuits, Tibet's mass monasticism did and remained sustainable over the long-term and resilient in the face of centuries of trade and political contacts with other cultures. In this sense, we should consider Tibet the "First Divergence" in human history supporting a relatively large non-agricultural proportion of its total population in educational pursuits. Even worker monks could usually attend an educational event each day, such as the first prayer session, or a daily prayer-tea, depending on their work schedule (Cabazon and Dorjee 2019).

The Western model of social development contends that mass education only follows industrialization yet Tibet was able to employ up to about twelve percent of its population as academics, effectively skipping the interim step. The governmental ideology of the Ganden Podrang government under the Dalai Lama's ca. 1642 -1950 was to support as many people as possible to study Buddhism in the attempt to gain enlightenment. One possible reason why this was economically feasible was that many of the wage or profit-seeking occupations of Medieval Europe such as grain lenders and artistry were functionally performed by Tibetan clerics. For example, some monks worked as

grain keepers who strove to accrue profits for their corporate-like religious orders with interest-bearing loans in grain while taking a commission. The monasteries and the individual orders functioned in place of a stable, secular government, training and preparing individuals in crafts, arts, and religious rites that might have escaped them had they stayed on the family farm. A broad net was cast for talent and those talents cultivated for the financial stability and political legitimacy of their orders.

The elucidation of how Tibet developed in such ways is complex and beyond the scope of this paper to completely unravel; however, confirmation of the relatively large ratio of clerics compared to the population in Tibet and understanding of spatial demographic distributions begs the question of how Tibet achieved large-scale education and why the same phenomenon is not seen anywhere else before the 19th and 20th centuries. Theories of linear social development should be expanded to include several possibilities or bifurcation points that reflect adaptations such as mass monasticism in Tibet. The variables and dynamics that led to demographic and economic stability through monastic life on the Plateau will be better understood through such further research.

H. Conclusion

This paper presented a land-use and consumption model that estimated the historical population of Tibet by sub-region and replicated the assumption that clerics constituted a historically significant proportion of the Tibetan population as compared to a recovered clerical census. Modeled population distribution largely matched China's 1990 census distribution though some differences were detected. Further, the spatial model disaggregated the results and revealed geographic variation, clustering, and special cases where population density was not clearly synonymous with clerical populations.

Most importantly, this study revealed significant geographic variation to the proportions of monks and nuns in Tibet historically. The often guessed-at figure in scholarship that monks comprised a quarter of the males or about 12 percent of the total population should now be generalized at 9 percent. And, it should be recognized nuns also comprised a significant percentage of the total population at about 3 percent. Furthermore, in some peripheral regions, nuns actually outnumbered monks. In fact, it would be more accurate for studies to acknowledge the large role women played in Tibet's religious life too and refer instead to a general clerical proportion of both nuns and monks that comprised about 12 percent of the total population.

Confirmation of a large clerical class focused on study and enlightenment seems at first glance to be incredibly taxing for a pre-modern society and raises questions about how such a divergence from the rest of the world in terms of social organization was possible or sustainable. However, traditional cultural practices and social norms led to the Tibetan population remaining relatively stable while supporting mass monasticism. Adaptively, clerics took on functional roles in the economy, whether it be labor or investment, and therefore supported agricultural sustainability and growth while also performing their religious duties and pursuing advanced education. And, this socioeconomic system clearly functioned across Tibetan society as a whole as seen in comparably high levels of monasticism in all parts of Tibet, such as Ngari, Kham, and Amdo, and it would be highly informative for both Tibetan studies and world history to expand this study's methodology to these regions based on the clerical census data for parts of Ngari and Kham not examined in this present study, and also similarly detailed historical listings of monasteries and monks in other parts of Kham and also for Amdo, to provide more regional comparisons.

Supplementary Materials

Replication data and the Python scripts used to prepare data and perform calculations can be found on Harvard Dataverse: https://doi.org/10.7910/DVN/C7ZKCD.

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