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Agricultural Development in a Tibetan Township

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With small land sizes, precarious food balances, and a changing institutional landscape, farmers in Central Tibet have had to be resilient and adaptive in their livelihood strategies. Rural Tibetans retain a base in semi-subsistence agriculture from which to pursue other major opportunities that have arisen in the 2000s, including off-farm work and caterpillar fungus collection. As reported in this paper, farmers have been given a further boost in recent years through buoyant food markets, and after decades of neglect, increased policy attention to agriculture. This has increased household wealth and reduced vulnerability, but with very low surpluses has had a limited effect on cash income, the vast majority of which must still be sourced off-farm. Thus, semi-subsistence agriculture provides a 'pathway out of poverty' including into the non-farm sector, but the transition will not be linear and will be influenced by a complex combination of forces.

The paper documents the way that these forces have played out at the household level in the case study township of Duopozhang in Shannan Prefecture between 2010 and 2015. Analysis is based on an agricultural-economic-biophysical household model populated by detailed household surveys, and contextualized and cross-verified with detailed primary and secondary data at township up to autonomous region levels. This may shed light on recent developments in agricultural areas of Central Tibet that are not easily accessible or widely reported.

Keywords: Tibet, agriculture, economy, development, China.

Introduction

Subsistence agriculture has been practiced in the central valleys of Tibet for millennia and endures as the base for livelihood strategies today. Resilient communities have adapted to powerful drivers of change including interventionist government policy and programs, rapid economic development and urbanization in the broader economy, new technologies and, most recently, burgeoning food markets. Impacts vary by area and household (Bauer et al 2010) from increased incomes especially from off-farm work (Goldstein et al 2010), to increased marginalization (Fischer 2013) and stratification (Goldstein et al 2003)—or for some areas and households little change at all.

This paper examines what is happening in the agricultural systems of central Tibet, why it is happening, and what is being done about it. Emphasis lies on structures at a household (micro) scale, but placed in context with developments at township (meso) and regional (macro) scales. Reporting on agricultural development may shed light on recent developments in agricultural areas of Central Tibet that are not easily accessible and not widely reported in recent years.

It does so through a case study of Duopozhang Township in a valley in Shannan (Lhoka) Prefecture, visited four times between 2011 and 2015 to conduct an economic analyses of a series of crop-livestock projects. The paper draws on detailed household interviews used to populate an economic and bio-physical model of agricultural systems in Duopozhang called *CAEGTibet*. These data are cross-verified with interviews with a range of agricultural actors (households, township and country officials, extension agents, researchers and agribusiness actors) and with statistics from township to autonomous region levels.

Small land sizes constrain on-farm incomes, but semi-subsistent agricultural systems provide security and a base from which households pursue other livelihood strategies (Fischer 2008). Over the 2000s, increased opportunities emerged for off-farm work, which has had a transformative effect in some areas like Shigatse making up around 70 percent of incomes (Goldstein et al 2010). With the explosion growth of caterpillar fungus markets and collection, the commodity makes up some 40 percent of rural cash incomes across the Tibet Autonomous Region (Yeh and Kunga 2013).

Seasonal off-farm work is practiced widely in Duopozhang and has increased in absolute terms in recent years. Off-farm income makes up around half of total incomes but the proportion has not increased in recent years. Reasons may include subdued demand for rural labor in Shannan,

a drop off in government construction and infrastructure programs in recent years, low surplus labor in summer months because of livestock chores, or because caterpillar fungus is not collected around the township.

Another contributing factor may be the rapid increase in agricultural prices in China and throughout Tibet since around 2007. Prior to this, food prices and especially grain prices were stagnant, and lagged overall price inflation between 1985 and 2005 (Goldstein 2008). Food prices have since risen dramatically, especially for livestock products which increased at *annual average* of around 15 percent. This has had significant upward pressure on total agricultural incomes, in particular on the value of own consumption and increase in value of livestock inventories, but with little surplus marketable agricultural production, only a small effect on cash incomes. In the 2010s, the state also renewed its focus on agriculture after years of neglect due to de-collectivization, fiscal decentralization (Goldstein 2008) and programs targeting non-agricultural activities like high-level infrastructure projects, education and health (Fischer 2011; Goldstein 2010). Renewed policy attention to agriculture has manifested itself in places like Duopozhang in the form of local-level infrastructure (land reclamation, water), extension services (breeding, disease) and subsidies (that total 24 different types in the township).

This is not to say that agriculture-led development is a panacea for rural development. The level of price increases for agricultural outputs began plateauing in 2014, while current policy support for agriculture may not be sustainable. More fundamentally, farm sizes are simply too small to produce significant surpluses for cash income demanded in modern Tibetan society, while measures to increase productivity can be resistant to uptake. Thus, social, economic and cultural transformations driven by livelihoods diversification, off-farm work and urban migration do seem irreversible (Fischer 2010; Bauer et al 2010).

However, this paper and numerous other accounts of rural Tibet also show that the trajectory is far from linear or straightforward. Households have been pulled in different directions—but generally benefitted—from periodic stimuli, the most recent being an era of high agricultural prices in which this study is set. Throughout these periods, highly resilient communities in Duopozhang have continued to adapt livelihood strategies based on finely balanced—but changing—semi-subsistence agricultural systems examined in the paper.

Methodology

This paper provides an analysis of household agricultural systems in agricultural areas of Eastern Tibet. The research

on which this paper is based was designed to provide an economic analysis of two collaborative, multi-disciplinary Sino-Australian projects on crop-livestock systems and livestock mineral nutrition in Tibet.¹ The research did not aim to explicitly examine social or institutional structures and change in the township, but these were necessarily considered as part of the agricultural development process. No attempt has been made to analyze or draw findings on questions of agency. Thus the paper provides a micro-structuralist analysis of agricultural and economic structures at the household level, but in context with broader macro settings and drivers of change.

The agro-economic research was conducted in three other sites in Shannan, Shigatse and Lhasa, but focused on Duopozhang Township between 2011 and 2013 through ongoing monitoring and trials, and the township was visited again in 2015. Duopozhang is a research and trial site for several research and development projects of the Tibetan Academy of Agricultural Science and the Tibet Poverty Alleviation Office. The township was selected for these projects because: it is broadly representative of agricultural areas in Shannan Prefecture; the agricultural sector is relatively undeveloped with potential for productivity gains; and because a bridge repaired in 2011 makes the township easily accessible to the prefecture center of Zedang. Duopozhang may therefore provide guidance to what is happening or might happen in other parts of Central Tibet if agricultural systems and technologies trialed in Duopozhang are scaled out. Duopozhang received higher levels of technical and policy attention from government than other sites worked in, which may bias findings especially on the role of the state in agricultural development. At the same time however, development initiatives of one form or another are ubiquitous throughout Tibet, and form part of the research and development landscape in Tibet.

The analysis draws on multiple sources of data— household interviews, interviews with other local actors (township officials, extension agents, agribusiness), technical information and reports, and statistics from township to autonomous region levels. The data has been cross-verified and inconsistent data discounted, to provide what is believed to be a robust picture of agricultural development in the township.

Analysis is centered on a household economic, farming systems and biophysical model of agricultural areas of Tibet called *CAEGTibet*. For details on the design, structure and findings from the modeling see CAEG (2011) and Brown and Waldron (2013). For the purposes of this paper, *CAEGTibet* is used primarily to reconcile household

production, consumption and balances of ‘representative’ households. The model was developed between 2009 and 2013 and populated with primary and secondary data from three research sites in Shigatse, Shannan and Lhasa. With the model already developed and tested in crop-livestock systems in other areas, data collection in Duopozhang focused on local model calibration and eliciting similarities and differences with other areas.

Calibration of the model drew on technical and trial information, but primarily on household interviews. Interviews were conducted based on the format of the model input sheets (household demographics, land use, cropping, livestock numbers, rations, household consumption, prices, financial information and subsidies). Data required was largely quantitative in nature, but framing, interpreting and converting this information revealed much about the broader household systems. Large scope was provided in the semi-structured interviews for qualitative information and free-ranging discussion that lasted at least three hours per household.

To gain an initial understanding of agricultural structures in Duopozhang, a focus group discussion was conducted in 2011 with 12 farmers participating in a mineral block project, which was broken up into five individual household pilot surveys. This was followed with more detailed and formal surveys in 2013. Township officials and project collaborators provided the agronomic and economic data required to categorize and select groups and households for surveys. Four of the eight village groups in the township were selected for surveys. Within each group, three households in each of three income strata (low, mid, high) were selected and interviewed. Rather than using quantitative criteria, the households were nominated by local hosts (extension officers) based on community understanding of ‘poor,’ ‘rich,’ and ‘in-between.’ Subsequent interviews and modelling results showed a good correlation between community understanding and calculated income levels though reasons varied considerably (land size, labor, livestock numbers). Middle income households in Group 3 were used as the ‘representative household’ for the township, from which a large number of variations and scenarios were run.

While 36 surveys (12 percent of households in the township) is a small sample size, this was sufficient to calibrate the model to provide consistent results that were deemed credible when tested with researchers and officials very familiar with the systems. Limits in the number of surveys were the trade-off for the long and in-depth household interviews required to calibrate *CAEGTibet*, which could not be done by enumerators.

The research team consisted of two Australian researchers, Tibetan-speaking colleagues in TAAAS, and one local who was generally the group livestock extension officer and in charge of finding the households, making the introductions, but who did not intervene in the interviews. If available, the adult male was usually interviewed, but they were frequently not at home, so wives or elders were also interviewed, and multiple generations or husband-wife teams were often interviewed. Even if households were aware of or participated in the agricultural projects that were conducted in the township, they are unlikely to have an interest or incentive to bias answers. Answers were translated from Tibetan into Chinese or English and transcribed by an Australian researcher.

The household data and analysis was complemented by data and information collected in 2011, 2013 and 2015 through meetings and interviews with township leaders, group leaders, agricultural extension staff, vets, artificial insemination staff, county officials, traders and retailers. Township officials interviewed were aware of or sometimes participated in the research projects, and were therefore forthcoming with data. No attempt was made by the busy officials to select or accompany the research team in the household interviews. There was unrestricted opportunity to wander around the attractive township and hills and talk to residents. All interviews were transcribed. Research partners with long-standing projects in Duopozhang, some of which were stationed in nearby Zedang, were key sources of knowledge.

A final source of data used in the paper is secondary data collected from the township and other reported data mainly from statistical yearbooks from country to prefecture levels, as discussed below. While these sources can be highly aggregated or inaccurate, the data shows consistent patterns over time. The yearbooks are not used to establish phenomenon in Duopozhang, but to cross-verify or to provide regional context to fieldwork data that cannot be gathered from other sources.

While the data collection and analysis methods provide a robust picture of agricultural structures and change in Duopozhang, the research is subject to several limitations. With a focus on agriculture, the study does not examine other non-agricultural aspects of township structures including social services (health, education) or off-farm work or migration (by composition or destination). Neither do we analyze broader non-agricultural policy, governance or gender dimensions. The detailed township case study comes at the expense of being able to generalize findings across broader areas, although some attempt has been done so through macro statistics and

brief comparisons with other studies. The vast bulk of research in Duopozhang was conducted from 2011–2013, and thereby precludes a longer longitudinal analysis. Conditions changed somewhat since that period, for example growth in agricultural prices had moderated by 2015, but a brief return visit in May 2015 confirmed the trends, observations and findings from the analysis based on the earlier data.

The paper is structured to provide a descriptive overview of Duopozhang Township, followed by an overview of major drivers of change that are exerted at higher and exogenous levels (in China and Tibet). These *drivers* apply *pressures, states, impacts* and *responses* at household and local levels,² which are analyzed in the paper through the sub-sectors of cropping, livestock, markets, and agricultural services. The paper concludes with observations about agricultural development issues in Duopozhang with reference to recent case studies in rural areas of Tibet (Bauer et al 2010).

The Case of Duopozhang Township

Duopozhang Township is located in Naidong (*sne gdong rd-zong*) County in Shannan (Lhoka) Prefecture to the south-east of Lhasa (see Figure 1). Naidong County consists of five townships and two towns, of which Duopozhang is the smallest with a population of around only 1,700 on 180,000 square kilometers of land. Duopozhang lies in a valley that feeds into the northern bank of the Yalu Zangbu (Yarlung Tsangpo) River which runs west to east and supports life in much of the agricultural areas in Tibet. The township has traditionally been difficult to access, but a bridge constructed in 2000 and repaired in 2011 means it is now only 20 kilometers or 30 minutes drive from Zedang (Tsethang), a town of 15,000 people located in Naidong County (pop 62,200) but that acts as the prefecture seat of Shannan (population 318,000). Zedang is a further 150 kilometers from Lhasa. By 2015, another road had been constructed in the northern side of the Yarlung, further shortening travel times to Lhasa.

Like other areas on the Tibetan plateau, Duopozhang experiences harsh and variable weather conditions. Temperatures average 6°C but drop below minus 10°C in winter, limiting many agricultural and human activities. The average annual rainfall is just 410mm of which the vast majority falls from June to September. Mountains feed rain and snowmelt into a stream that flows through the valley for use by irrigation, livestock and households.

The valley forms a micro-climate, but there are marked differences in agro-climatic, bio-physical and topological

	Bumai 1	Bumai 2	Bumai 3	Bumai 4	Bumai Village	Suolang 1	Suolang 2	Suolang 3	Suolang 4	Suolang Village	Total Township
Population	217	282	219	192	906	214	224	158	224	817	1,1723
Number of households	57	62	58	49	226	51	56	41	48	196	422
Average persons per household	4.2	5.0	4.8	4.3	4.6	4.1	4.3	4.3	5.0	4.4	4.5
Labor force	113	157	116	106	492	101	129	101	129	460	952

Table 1. Demographic characteristics of natural villages in Duopozhang, 2012.

(Duopozhang Township government statistics)

conditions within the township. The top of the valley is mountainous and steep with small areas of arable land. Households at the top of the valley are more pastoral than agricultural with livelihoods revolving around grazing yak on the mountain grassland. Groups in middle parts of the valley have larger areas of cultivated land and access to irrigation water, but also graze livestock especially *dzo* (a cross between yak and cattle) and yak in summer mountain areas. Lower reaches of the valley have access to more level cropland, but this leads into dry, sandy and acidic soils especially in some of the reclaimed lands closer to the river. The township as a whole is classed as semi-pastoral, as a significant proportion of the agricultural income is derived from livestock and grazing.

The de-collectivization process in Duopozhang is similar to other parts of rural China. Ownership rights over livestock were distributed in 1982. In the same year, use rights for cultivated land were fully allocated to households on the basis of two to three *mu*³ per person. Land can be reallocated if for example a family member moves permanently out of the village, but not usually through births and deaths in the family or temporary informal work outside the village. Any building on households land must be approved by the collective (village) and government (township and country). Use rights on mountain land for grazing have only recently—in 2011—been allocated to households, later than other pastoral areas of China. Households now have contracts over land used for cutting, for grazing or that is planted to trees.

Duopozhang comprises two administrative villages—Bumai and Suolang—and eight natural villages (or groups) that are strung out along the length of the valley. For Duopozhang as a whole in 2012, the average number of households per group is 52, each has an average of 4.08

members, making a population in each of the natural villages of around 215. Through natural and administrative planning, each of the groups have similar numbers of households, but there are slightly fewer households at the top end of the valley (Suolang) compared with the lower end of the valley (Bumai) where more cropping land is available (Table 1).

Duopozhang has had only a modest increase in overall human population. There has been no in-migration of (re-settled) people to Duopozhang, however there have been some changes in household structure within the township. In Suolang Group 3, household numbers increased by 26 percent in the two years of 2011-12, because of the land reclamation mentioned above. In other groups, the number of households increased by six to eight percent as children (sons) started new families. At the same time, however, total populations decreased by one percent in Bumai and 0.4 percent in Suolang due to deaths and out-migration of registered people. As a result, the average number of family members per household in Duopozhang reduced from 4.5 to 4.08 between 2010 and 2012. Township officials cited a decrease in polyandry and an increase in urban migration and education in outside areas or mainland China, but also said that these movements can be temporary, and the movements are often not recorded in township population statistics. Perhaps reflecting this, the labor force of Duopozhang (residents between 18 and 60 years of age) made up 55 percent of the population, up slightly from 53 percent in 2010.

While these human populations are not large and decreasing, they have to be seen in context of small cultivated land areas, of around 2.3 *mu* per person, on which households rely for most of their food and much of their feed (Table 2). Much of the cultivated land in Duopozhang,

	Bumai 1	Bumai 2	Bumai 3	Bumai 4	Bumai Village	Suol- ang 1	Suol- ang 2	Suol- ang 3	Suol- ang 4	Suolang Village	Duopozhang Township
Land Area (mu)											
Cereals	557	647	473	371	2,012	575	556	376	380	1,887	3,899
Fodder crops	84	84	250	70	488	200	80	65	68	413	901
Other crops	200	180	30	52	462	1,100	96	80	190	1,466	1,928
Irrigated land	841	911	717	492	2,961	1,360	732	521	639	3,252	6,213
Grazing land	44,134	47,831	14,794	23,670	130,429	26,664	30,361	19,115	53,790	129,930	260,359
Cutting land	300	180	250	52	782	200	80	65	68	413	1,195
Other land	841	5,000 (sand)	5,000		5,841	1,360	732	521	638	3,251	9,092
Percent of households with											
<10 mu	60	70	90	94	78	40	66	65	50	55	67
>15 mu	40	30	10	6	22	60	34	35	50	45	37
Land per household (mu)											
Cereals	10	11	8	8	9	11	10	9	8	10	9
Fodder crops	2	1	5	1	2	4	1	2	1	2	2
Other crops	4	3	1	1	2	22	2	2	4	8	5
Irrigated land	15	15	14	10	14	27	13	13	13	17	15
Grazing land	774	797	285	483	592	523	542	466	1121	663	625
Cutting land	5	3	5	1	4	4	1	2	1	2	3

Table 2. Land use and cropping areas in Duopozhang, 2012.

(Duopozhang Township government statistics)

especially higher in the valley, are terraced fields. The majority of households in the township base their livelihoods on about 10 *mu* (or two-thirds of a hectare) of cultivated land, roughly the same size as average farms in intensive cropping areas like the Central Plains of China and yellow soil areas of Gansu but with a shorter growing season and higher yields.

Of the cultivated land in Duopozhang, around 53 percent is grown to cereals, twelve percent to fodder crops and the remainder to other crops like potatoes (Table 2).⁴ Unlike many agricultural areas in Tibet where spring barley is the staple cereal crop, winter wheat predominates in Duopozhang, accounting for 42 percent of the cultivated land area. These data changed little between 2010 and 2012.

Livestock type and numbers are also intricately connected to land use patterns in the township. Crop residues (straw

and the grazing of stubble are used for livestock feed. Small amounts of land are dedicated to fodder crops and (grass) cutting for livestock feed. The township has access to large grazing areas (247,500 *mu* of which 1,760 *mu* is “improved”) which is used only seasonally.

Of the approximately 14,000 head of livestock in Duopozhang in 2012, 4,619 were large ruminants, especially yaks and cattle (see Table 3), up 5.5 percent from 2010. There are more yaks in Suolang because of the larger areas of high, remote grasslands, while there are more dairy cattle in Bumai because of the greater availability of crop residues and other feed for intensive feeding. Duopozhang also has more than 6,000 sheep and goats, roughly the same as in 2010. Goats are evenly distributed across the two villages but Suolang had fewer sheep because they are less well adapted to the high mountain areas and grasslands dominated by a leguminous feed shrub but that can entangle the wool with thorns (*Saphora viciifolia*). While

	Bumai 1	Bumai 2	Bumai 3	Bumai 4	Bumai Village	Suol- ang 1	Suol- ang 2	Suol- ang 3	Suol- ang 4	Suolang Village	Township
Livestock numbers (head)											
Total Livestock	1,540	2,583	1,292	1,318	6,733	1,876	1,671	1,428	2,179	7,154	13,887
Local cows	169	236	308	203	916	208	180	171	169	728	1,644
Improved cows	63	72	58	62	255	54	58	42	80	234	489
Yak	283	320	95	268	966	389	416	128	587	1,520	2,486
Sheep	278	1,051	182	107	1,618	174	211	65	373	823	2,441
Goats	311	525	514	560	1,910	408	374	710	540	2,032	3,942
Pigs	70	61	60	50	241	60	72	72	54	258	499
Chickens	366	318	75	68	827	583	360	240	376	1,559	2,386
Livestock per household (head)											
Local cows	3	4	6	4	4	4	3	4	4	4	4
Improved cows	1	1	1	1	1	1	1	1	2	1	1
Yaks	5	5	2	5	4	8	7	3	12	8	6
Sheep	5	18	4	2	7	3	4	2	8	4	6
Goats	5	9	10	11	8	8	7	17	11	10	9
Pigs	1	1	1	1	1	1	1	2	1	1	1
Chickens	6	5	1	1	4	11	6	6	8	8	6

Table 3. Livestock in Duopozhang, 2012.

(Duopozhang Township government statistics)

ruminant livestock predominate in Duopozhang, most households also raise hens and a pig or two for fattening.

In 2012, the GDP of Duopozhang was Rmb17,974,000, an increase of 22 percent over 2011 and 46 percent over 2010. Of this, 60 percent was from primary industry (agriculture). Given the small growth in stock numbers, increase is largely attributable to increasing agricultural prices. With no secondary industry, the remaining 40 percent of GDP derived from tertiary industry (services including trading, transport, construction, off-farm work and transfers).

Rural net per capita incomes were Rmb5,982 in 2012, an increase of seventeen percent over 2011, slightly higher than the TAR average of Rmb5,719 and slightly lower than the Shannan average of Rmb6,056. These net incomes are based on the value of production (outputs multiplied by average prices), sales and off-farm income. Of this, cash income (agricultural product sales and off-farm work, not accounting for own consumption) was Rmb3,760 (up seventeen percent on 2011). Given that little surplus agricultural product is sold out, off-farm income accounts for around 50-60 percent of total incomes.⁵

While this proportion is significant, it is less than that reported by Goldstein (2010) in Shigatse and in a nearby peri-urban area in Zedang.⁶ Township officials attributed this to the relatively low demand for off-farm labor in Shannan, compared to Lhasa and areas to the west of Lhasa, and other factors are discussed below.

While data on income equality in the township is limited, indicators can be derived from township statistics. Compared to Duopozhang averages, cash incomes were only three percent higher in Suolang administrative village and three percent lower in Bumai. There are however some significant inter-group differences. For example, average cash incomes were eighteen percent higher in Suolang Group 4 and seventeen percent lower in Bumai Group 2. For inter-household differences, CAEG modelling reveals some of the income effects of different levels of agricultural productivity. For example, dairy farmers that adopt improved systems (forages and mineral blocks) can have net incomes 42 percent above “low productivity” systems. Low income households interviewed in Duopozhang all tended to have a shortage of household labor, especially widows or families where men had embarked on long pilgrimages.

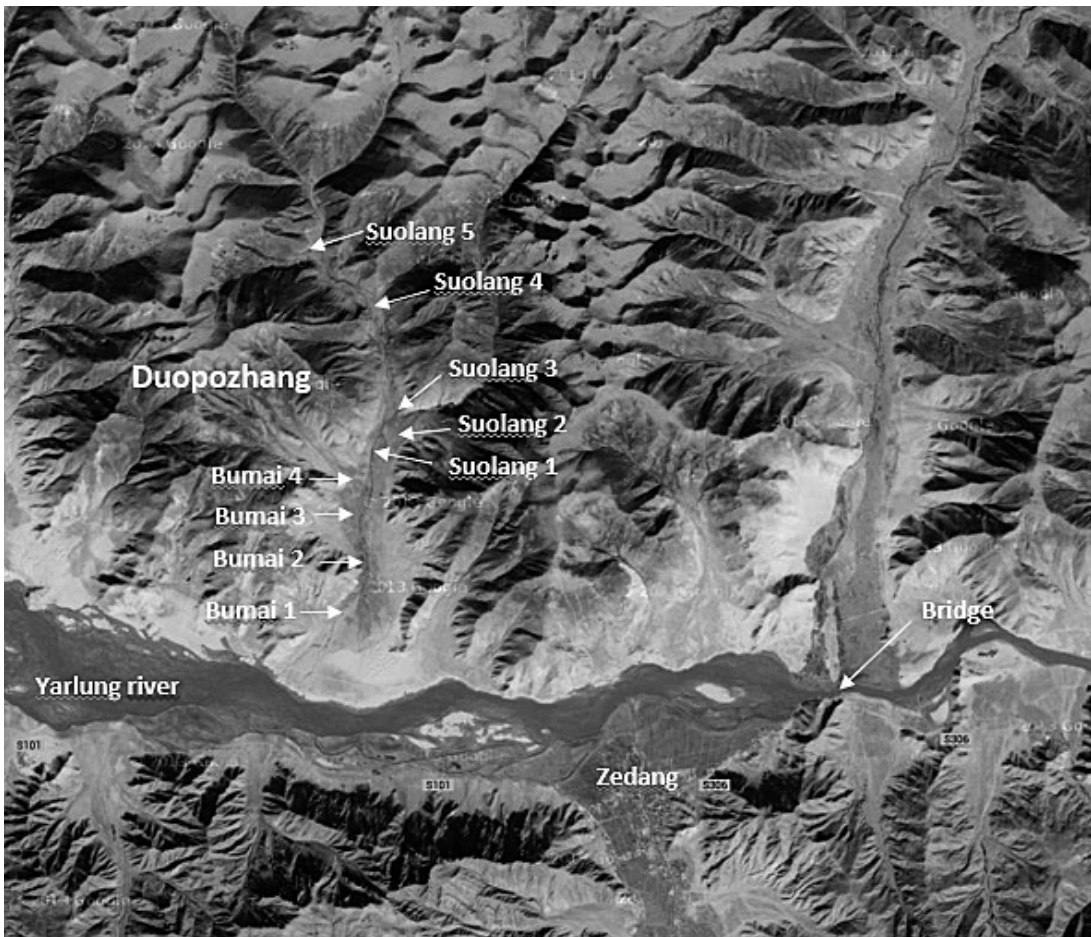


Figure 1. Location of Duopozhang Township.

Access to higher paying, more seasonally consistent and permanent off-farm work (i.e. remittances) was common in high-income households.

Drivers of Change

Agricultural systems in Duopozhang have been forged over many years by a combination of customary practices, new technologies and government interventions. Livelihoods and day-to-day activities still center around grazing animals, milk churning and weaving, building communal infrastructure and cultural activities. The community has shown remarkable resilience in maintaining agricultural livelihoods and strong cultural traditions.

While these structures still predominate, Duopozhang is changing through a series of higher-level ‘external’ drivers that are the focus of this section. These are analyzed below as economic and sectoral growth, population growth and demographic change, change in relative incomes, and infrastructure policy drivers. Subsequent sections show that the way these drivers are described at a high level can be very different and virtually unrecognizable at local levels.

Incomes and Off-farm Work

Prefectures like Shannan and counties like Naidong are not insulated from the sustained rapid economic growth occurring in Tibet and China. Average per capita rural incomes in Tibet increased rapidly from just Rmb1,211 in 2000 to Rmb3,504 in 2010 to Rmb5,179 in 2012, a (compounded) average annual increase of 13.7 percent.⁷ These levels and increases are comparable to those of Shannan Prefecture of Rmb1,298, Rmb3,676 and Rmb6,056 (12.5 percent) and to those reported for Duopozhang in 2010 and 2012.

While absolute incomes have increased, pressures experienced in society also derive from differentials in incomes between areas and households (relative incomes). Incomes in Tibet are 70 percent the national average and consistently rank among the lowest of all provinces and autonomous regions in China. Furthermore the gap between urban and rural incomes is among the highest in China with rural net per capita incomes only 30 percent of disposable urban per capita incomes in 2012 (Tibet Statistical Yearbook, 2013). However, this level is up from 26 percent in 2009 conforming to findings from Fischer (2010) that the urban-rural gap has narrowed in recent years.

These relativities have implications for the opportunity costs of agricultural labor and incentives to work off-farm, and places pressure on governments to devise policies to increase rural incomes. Within the net incomes of rural Tibetans, the proportion of wage incomes increased from

virtually zero to seventeen percent by 2009 (Tibet Bureau of Statistics, various years). Case studies and surveys also document the rapid increase in off-farm work in rural Tibet and opportunities for entrepreneurship and integration with the broader Chinese economy (Goldstein et al 2008; Childs et al 2010). Nevertheless, compared to ‘inland China’ where off-farm work and rural migration have transformed rural landscapes, livelihoods in rural Tibet remain rooted in agriculture, accounting for 70 percent of incomes in 2010 and 71 percent in 2012 (Tibet Bureau of Statistics, various years).

The proportion of wages in total rural income levelled out at seventeen percent in 2009 and 2012, and in Shannan were eighteen percent in 2010, 20 percent in 2011 and seventeen percent in 2012 (Tibet Bureau of Statistics, various years). That is, in the context of increasing total incomes, wage incomes have increased in absolute terms, but not as a proportion of total incomes. This is because on-farm incomes increased by the same margins due to increasing agricultural prices. These trends also appear to be mirrored in the incomes and income composition of households in Duopozhang.

Demand and Prices

Income growth and urbanization in China including Tibet has increased the demand for agricultural products, but in an environment of supply-side constraints including land and opportunity cost of labor. This has led to rising prices for agricultural commodities, especially livestock meat and dairy products. For example, between January 2007 and December 2013, average *annual* price increases in China (compounded) were eighteen percent for mutton, eighteen percent of mutton, eight percent for pork and four percent for eggs. Prices increases were even higher between 2010-12 of nineteen percent for mutton, 22 percent for beef, ten percent for pork, nine percent eggs and seven percent milk (Editorial Board of the China Animal Husbandry Yearbook, various years). In Tibet, from 2007-13, the annual average increase in the consumer price index for “meat, poultry and their products” was 112 and for grains was 106 (Table 4). Some specialty products from Tibet—butter, eggs and yoghurt—also attract significant premiums in urban markets in Tibet and eastern China (see Brown et al 2011). At the same time, price indices for agricultural inputs (fertilizer, pesticides, machinery, services) were stagnant or declined, partly due to subsidies. As shown in Section 6, price increases for agricultural outputs have a large impact on rural incomes (in assets, consumption or cash) in Duopozhang.

Year	Meat, poultry and their products	Grains	Fertilisers and pesticides
2007	120	109	99.8
2008	126	104	99.9
2009	0	100	100
2010	102	107	100
2011	112	112	100
2012	109	103	100
2013	113	106	100
Average 2007-13	112	106	100
Average 2011-18	111	108	100

Table 4. Consumer price indices for agricultural commodities in Tibet (percent annual increase).

(Tibet Statistical Yearbook, various years)

Sectoral Change

Changing demand patterns are reflected in structural change in the agricultural sector. Within the gross output value of agriculture in TAR, cropping accounted for 50 percent in 2000, 48 percent in 2006 and 47 percent in 2013. This pattern was also evident in major cropping areas like Shigatse, where the proportions fell from 66 percent to 60 percent to 59 percent, but there are significant regional differences. For example, the proportions in Shannan fell more dramatically from 61 to 51 to 47 percent, while the proportion of livestock increased from 38 to 35 to 44 percent.

Within the cropping sector, the area of cultivated land planted to grains fell from 87 percent in 2000 to 71 percent in 2013, and was taken up by oilseeds and fodder for livestock. Although overall livestock numbers have reduced significantly especially since 2010, there was a switch in the makeup of the sector from small ruminants (sheep and goats) to large ruminants (cattle). Meat, especially bovine meat, output increased significantly, reflecting more commercialized production systems. Structural change was also facilitated by Central and Tibetan government policy from the end of the 1990s, when autonomous region grain production and self-sufficiency targets were deemed to have been met, and livestock and fodder crops were actively promoted.

The vast majority of rural Tibetans, however, still consume much of their own produce. Grain sold as a proportion of grain produced has risen but only from eleven percent in 1995 to fifteen percent in 2007, while the proportion of canola sold to production remained the same at around 22 percent over the same period (Fan 2007). These proportions are similar to those calculated in household modeling in Duopozhang.

Population

Population growth represents another driver of change in Tibet. Natural population increase rates in Tibet in 2012 were 1.04 percent per annum or twice the national average, due especially to relaxed family planning policies for ethnic minorities (National Bureau of Statistics 2013) but in the context of declining fertility (Childs et al 2005, Fischer 2013: 83-126). The number of rural households increased from 313,000 in 1980 to 539,800 in 2013 (Tibet Bureau of Statistics 2013), while the number of agricultural workers increased from 0.8 to 1.3 million in 2013 (Tibet Bureau of Statistics 2013). At the same time, however, the proportion of the rural population in the total population decreased from 84 percent in 1990 to 76 percent by 2009. However, the movement is less pronounced than elsewhere in China and proportions in Tibet had leveled out at 76 percent in 2013. While these trends of high relative population growth, and low relative urbanization, apply at the TAR level, these trends vary across TAR. Township data show an absolute decline in population growth in Duopozhang, but also the enormous pressure that humans and livestock exert on land, and the fine balance between food self-sufficiency, surpluses and deficits.

Policy Drivers

Agricultural development and the livelihoods of rural Tibetans are impacted directly and indirectly by agricultural policy. While a complete policy analysis is not possible here, the following lists major policy changes relevant to agriculture by five-year plan period.

The 10th Five-year Plan (2001-2005), which coincided with early stages of the 'Develop the West' campaign, empha-

sized economic growth, especially through infrastructure (transport, power, water). The program was criticized for scant attention to cropping and livestock; sectors which were of most direct importance to the livelihoods of Tibetans and poverty alleviation (Goldstein et al 2010; Fischer 2005). Agricultural investment from TAR budget allocations was low and declining in relative terms, while only six percent of central government funding to Tibet directed to agriculture, and this targeted food self-sufficiency within Tibet especially in cereals through irrigation and plant breeding (Fan 2007).

While 'hard' infrastructure and a 'technocratic' approach to development remained, the 11th Five-year Plan (2005-2009) incorporated a 'people first' approach to development that aimed to improve more directly the quality of life in rural areas. This meant increased funding for 'soft' development targets (education, health, culture, science and technology, village roads and eco-environmental projects) and village-based projects to increase agricultural production for market (Goldstein 2010). Billions of Renminbi were directed to agricultural modernization and structural adjustment programs to facilitate off-farm employment and urbanization and to develop agricultural enterprises. With statistics indicating that Tibet had become largely self-sufficient in grains, policy attention turned to the development of livestock and specialty Tibetan products (e.g. yak meat and milk, Tibetan eggs). Grassland condition became a policy issue (Fan et al 2007; Tibet Daily 2009).

There was continuity into the 12th Five-year Plan (2010-2015), which had overarching aims to continue support for agricultural development, reduce rural poverty, increase incomes, increase food security, address agro-environmental problems and restructure the sectors along regional lines. To reduce grazing pressure on grasslands, stock numbers were to be halved in pastoral areas through culling unproductive animals and increased turnoff. To offset reduced grassland utilization, programs sought greater integration between pastoral and cropping areas (transport, marketing) and an increase in fodder production and preservation. Concern about the loss of land to barley production in particular was to be offset by increased technology, inputs and yields. In livestock, dairy was to be promoted in crop-livestock areas, yaks in central Tibet, cashmere goats in north and western Tibet, and sheep fattening was to be promoted across multiple areas (TAAAS, personal communication).

The drivers and policies discussed above manifest themselves in Duopozhang agricultural systems, discussed be-

low in the sectors of cropping and livestock, and especially in the delivery of agricultural services and subsidies.

Cropping

The representative household in Duopozhang modeled in *CAEGTibet* has eleven *mu* of land, on which it plants 1.5 *mu* of oilseed, one *mu* of potatoes, one *mu* of spring barley and eight *mu* of winter wheat – the main cereal in Duopozhang. Although growing seasons are limited by a protracted winter, very high levels of radiation in Tibet, high fertilizer application rates and sufficient water for irrigation in most seasons mean that yields are relatively high. Various crop rotation, relay or inter-cropping options are available. Wheat yields in an average season are around 350kg per *mu*, which on eight *mu* of land produces 2.8 tons of grain and about 5 tons of straw.

A typical household of four people will use this wheat grain for:

- Own consumption of dumplings (*momo*) and flat bread (200kg).

- Exchange for rice (200kg of rice equates to 460kg of wheat), barley flour (*tsampa*) and beer (on a 1:1 basis) and other products like salt (around 100kg of wheat per year).

- Carry-over seed and storage losses.

- Livestock feed. Six hens and one piglet will consume 633kg of wheat, although this is often damaged grain.

In an average year, the representative household will produce sufficient wheat to meet their own consumption needs. However wheat deficits occur for households with small land areas, especially in upper reaches of the valley and amongst land-poor households. Dry seasons that limit irrigation water and reduce crop yields by around 30 percent also lead to wheat grain deficits. Households cope with the variation by storing grain over several years, limited by storage losses and grain toxicity.

Even if households meet their own subsistence food requirements, they produce limited surpluses that can be sold to meet cash needs. While grains provide much-needed supplementary feed for livestock to achieve even a moderate level of productivity, households are very unlikely to divert surplus grains to feed. Even with relatively little cereal in the feed rations, a sow and her litter will consume up to 1.33 tons of grain, while cows fed a ration of 20 percent of cereals and beer making grain wastes in winter and spring will consume around 270kg of grain.

Cropping systems in Duopozhang have evolved to adapt to constraints and seasonality, including terracing, irrigation, crop regimes (cultivation, planting, weeding, pest control, harvest, grazing) and cooperative labor (especially for harvesting). These systems are long-standing, have deep roots in customary practices and involve close coordination within the community, but have also been assimilated and formalized in government and collective systems.

The party-state has been pro-active in forging change in the cropping sector through numerous interventions and non-traditional measures. Agricultural land in Duopozhang (and across Tibet) is state-owned (unlike most of China where it is collective). Even though households hold use rights over their land, government effectively dictates and orchestrates major cropping activities, staggered according to agro-environmental conditions down the valley. Researchers, agricultural bureaus and the extension system use “science and technology” to decide on cropping regimes best suited to the township which extends to crop types, varieties, planting and harvest times, rotations and input use (water, fertilizer, pesticides). While there is some discretion, households effectively follow the program coordinated and implemented through the extension and local leadership structure. Change in farming systems is also facilitated through the ‘carrot’ of agricultural subsidies.

Given the reliance and variability in water supply for cropping in Duopozhang, one of the most important projects undertaken in the township is to increase water storage and supply through constructing three dams (two in Bumai and one in Suolang) funded by Central government. The water is used for irrigation of crops and forages including on reclaimed land.

Government has also sought to alleviate the tight limits on land sizes in the township through land reclamation and intra-township resettlement. Township government (through Rmb12 million funding from the Poverty Alleviation Office) reclaimed a gently sloping hillside area of 400 *mu* area in Bumai No. 3 Group. The land has been planted to lucerne (half dryland and half fed by a new dam) and use rights were allocated evenly to households in the group on the basis of 0.5 *mu* per family member. There are plans to reclaim another 800 *mu* (to total 1,200 *mu*) in Duopozhang.

An entire natural village was relocated from the very top of the Duopozhang valley in 2006, where steep land limited households to small plots (five *mu*) of terraced cultivation land, and limited water supply. The households relied on pastoral livestock production in high grassland mountains, especially yak, but where grasslands were said to be

degraded and living conditions harsh. There are still some herder huts, pens and feed in storage in the area, used by a herder that is contracted to manage large combined herds (800-900 head of sheep and goats for about 40 households).

The group was moved to the very bottom of the valley to become Bumai No. 1 (Figure 1). Households interviewed said that at first they did not want to move, especially as the land in Bumai No. 1 was harsh, rocky, sandy, acidic and treeless. However, the households became “used to it” and government installed dams, reclaimed land and planted trees, built lines of houses and courtyards and livestock pens. Water from the dams was used to irrigate crops and large amounts of fertilizer were applied. The households do not have access to hillside grazing areas and many of the households in Bumai No. 1 work off-farm because of the poor land and soil.

Livestock

Livestock are of course an integral part of the farming systems, diets and livelihoods of Tibetans. Livestock raised in Duopozhang include: yaks, *dzo*, sheep, goats (Ningxia and Boer breeds), pigs (Tibetan and introduced), cattle (local, Simmental, Holstein, Jerseys), and chickens (local and Lhasa North). Because of the importance of dairy products in Tibetan diets, the representative Duopozhang household raises one improved (Holstein-cross) cow and two local cows, both of which have low yields of 4.3 and 2.3 liters per day respectively in the peak season of June. In addition, most households keep a local bull for draught requirements, and an average of 20 sheep and goats.

The representative household produces milk from their cows (820kg per year) which is churned at home into butter (42kg) and cheese (67kg). This is not sufficient to meet consumption needs, so the representative household buys in another 18kg of butter and 13kg of cheese per year. The household has a few head of sheep, goats and pigs slaughtered for own consumption per year, as well as bovines in winter when larger carcasses can be preserved. However, most livestock are sold out of the household providing one the few sources of cash income.

Because livestock products are so important for own consumption and sales, households seek to maximize livestock numbers within their resource constraints, especially land (both cropping and grazing) and labor. Livestock activities are labor-intensive. The representative household with three cows and one bull requires half an adult labor unit over the course of the year for feeding, watering, herding, tethering, penning at night, vet care, breeding and butter

and cheese making. However, feed growth and intake and dairy output and processing are at their peak in the warmer months of the year, which more than doubles livestock labor demands.

Land size and condition also places major constraints on the type and number of livestock that can be produced. Households align livestock numbers to their own feed resources, especially straw. Straw is used to feed the cattle and small ruminants in winter and spring when pastures and cut grass are not available, while cattle also graze crop stubble after harvest in September. Supply of straw is limited by own production, and the logistics and cost of transporting, buying and storing large volumes of straw.

The feed requirements of the three cows and one bull amounts to 737 kilograms of cereal and 2,487 kilograms of straw, which can be met from the eleven *mu* of land of the representative household. However, the additional 20 head of sheep and goats places households at the very edge of their own-produced feed resources. In a normal year, the household would have to buy in modest amounts of grain and straw in winter and spring to maintain the condition of stock (let alone achieve good weight gain). In dry years, the household would have to buy in significant quantities of feed just to keep the animals alive. In practice, households rarely buy in feed, resulting in productivity losses that include weight and condition, decreased conception and birthing rates and mortalities, with large impacts on farm returns.⁸

Limits on cultivated land areas and crop residues have seen increased interest in forage production, including land reclamation for lucerne and the inter- or relay-cropping of vetch. Forage production is however limited by the wariness of both households and policy-makers to displace grain production for human consumption with forage production for livestock consumption ('food security').

Grazing and cut grass therefore provides most of the feed for ruminant livestock (sheep, goats, yak, dzo and cattle). Depending on the season, ruminant livestock graze on stubble, roadside, riverside, hill and mountain areas to which a household or group has grazing rights. Some of the pastures and roadside feeds are cut and carried back to the livestock in pens, but cattle and small ruminants are typically free-grazed or are herded during the day and penned at night next to or under the house. Dzo can be grazed and penned in intermediate altitude grasslands while yaks are herded, milked and sold from higher altitude grasslands over the warmer seasons.

Free access to the grasslands is crucial to the viability of livestock systems and livelihoods in Duopozhang. Even the modest livestock herds in the representative household consume almost 19 tons of dry biomass over the course of a year. The value of this pasture feed—that is, the opportunity cost of substituting with other equivalent energy value—is Rmb10,871 which, if incurred, makes livestock a very marginal activity (household returns of Rmb2,900). If government fully compensated households for the loss of grazing, the outlay would be Rmb4.2 million per annum, beyond the capacity of township coffers.

The 'free' access of households to grazing land, combined with pro-livestock policies and rising meat prices has increased livestock numbers in Duopozhang, which places pressure on environmentally fragile hill and mountain grasslands with grassland coverage of just eleven percent.⁹ While township officials say that grasslands in Duopozhang are not degraded, actual stocking rates are almost always higher than stocking rates set in household grassland contracts or government standards.¹⁰

This poses a major conundrum for local officials or, in the words of one, a "big headache." Households have held formal use rights over grasslands since 2011, the same year a revised national grasslands policy was implemented to enforce stocking rates and 'reward' households for compliance.¹¹ Township officials are, however, acutely aware of the impacts that enforcement would have on livestock numbers and the resistance it would meet.

To strategically comply to higher level directives while placating local constituents, local officials have distributed 'reward payments' and production subsidies to households, but asked to stop over-grazing and reduce their stocking rates over a three year period (notionally 30 percent in the first year, 40 percent in the second year, and 30 percent in the third year). In practice, pastoral groups and households interviewed had not reduced numbers over the period and it remains to be seen whether stocking rates will be enforced or even monitored.

Markets

Integration into markets can increase incomes and transform agricultural structures. Integration into product markets can lower input prices and increase output prices, land markets can allow some households to expand and others to leave the land, and labor markets allow households to pursue more lucrative employment and increase cash incomes. As shown in this section, buoyant food prices over an extended period have had a significant effect

on household wealth, broadly defined. However very small amounts of surplus production has limited the extent of direct integration into product markets, and therefore cash income from agriculture. With roots in agriculture providing a base for food security and livelihood strategies, households have shown little interest in renting out land. The section also presents data to suggest that integration into off-farm labor markets is constrained by limited surplus labor in the peak off-farm work season.

Product Markets

While agricultural markets have burgeoned in China and urban areas of Tibet, and Duopozhang is relatively close to an urban center, households in the township are not closely engaged with external markets. Table 5 provides estimates from township officials of the extent of trade in agricultural products in Duopozhang.¹² The vast majority of cereals, oilseeds, dairy products and fibers are self-consumed by households leaving low marketable surpluses. A modest proportion of products are traded or bartered within the groups or township to fill shortfalls in particular products, and reflecting agro-climatic differences within the township. The main products traded outside the township are livestock, meat and other crop products (the special case of potatoes). However, households do not often sell (or cull) livestock, especially cattle, *dzo* and yak, partly due to low growth rates and long periods to reach slaughter weight, and partly due to traditional practices of keeping animals even after productivity declines (Levine 1999).¹³

As shown in the macro figures above (meat prices and indices), agricultural prices have increased dramatically in re-

cent years in China, Tibet and Duopozhang. Based on these macro indicators and fieldwork data collected for 2010 and 2012,¹⁴ the income effects are shown in Table 6. The table also provides information on other sources of income (off-farm work and agricultural subsidies) discussed below.

Because of the low level of trade of most products outside the township, the vast majority of farm income is non-cash. Increasing agricultural prices in recent years have increased the value of own-consumed food (by eleven percent per year). Price increases have also lifted the value of household assets and household wealth (eighteen percent), especially in the form of livestock where price increases have been highest. Note that the model treats increase in livestock weight as an asset that is inter-changeable with sales if/when sold. Higher agricultural prices also have a positive effect on cash incomes, but only for a very limited amount of surplus product. With low and subsidized input prices, farm expenses increased by only two percent. As a result, net farm income has increased substantially by 21 percent (excluding the opportunity cost of household labor or capital). Off-farm income and subsidies play a part in total household incomes, as discussed below.

The research also examined agricultural marketing practices to examine their role or potential role in agricultural development. Households sell livestock mainly to traders from Zedang that operate as part of close-knit ethnic Hui slaughter and retailing networks (as also observed by Fischer 2008) and throughout Chinese ruminant livestock industries (Waldron 2010).¹⁵ Traders ring local contacts to check availability, travel to Duopozhang to negotiate, and then buy and truck the animals back to Zedang. Yaks are sold in their grazing location which is often high in the

Product	% Household consumption	% Trade in township	% Trade outside township
Livestock	20	30	50
Meat products	45	15	40
Dairy products	75	15	10
Wool & goat hair	78	15	7
Eggs & other livestock products	69	20	11
Manure	100	0	0
Cereals	95	0	5
Fodder	100	0	0
Oilseeds	90	10	0
Other crop products	40	0	60

Table 5. Trade in agricultural products in Duopozhang in 2012.

(Survey of Duopozhang Township officials)

mountain grasslands. This is a low-risk arrangement for farmers in the event of an unsuccessful negotiation, and there appears to be competition amongst buyers (although they all know each other). Information collected from traders, retailers and households suggests that downstream margins in downstream sectors are modest at just under fifteen percent and consistent with elsewhere in China.

Against this, purchase on-site means that traders can assess grassland and social conditions – and therefore the bargaining position – of sellers. Traders inevitably have better market information than farmers, can more accurately estimate liveweights and meat yields, especially as they or their relatives slaughter animals every day. Thus while a 35kg liveweight sheep can sell for around Rmb750, this price can conceivably be as low as Rmb550, which has a substantial impact on household incomes.

With improved road infrastructure and the bridge to Zedang, households visit Zedang to make irregular purchases and sales. Households can easily sell small amounts of butter or eggs to stall-holders in markets as local produce is seen as better quality than commercial product. With higher fat content and more yellow in color, local butter commands a price premium of about Rmb20/kg over butter from ‘inland China’. Eggs from native Tibetan chickens can be double those of commercial eggs.

Market signals such as these capture the imaginations of policy-makers and investors but face major challenges in increasing production, aggregation and logistics (see Brown et al 2012).

Labor Markets

With wages of Rmb60 per day or Rmb1,000 per month in 2012, rural households regard off-farm work as important, and all but the poorest (especially elderly widowed) households have at least one family member that works off-farm for at least some time, especially in transport and construction or furniture-making. Some households have children or grandchildren working in Zedang, Lhasa or other cities on a more permanent basis that send remittances back to the household.¹⁶ These revenues are clearly important for cash expenses and household needs making up between 50 percent and 60 percent of household incomes (in township statistics above) and around 50 percent calculated using CAEGTibet (Table 6). Note that higher agricultural prices in recent years have reduced slightly the proportions to 47 percent (Table 6).¹⁷

Off-farm work, however, has yet to transform rural areas like Duopozhang in the way that it has in ‘inland China.’ Despite widely-heralded training programs, farmers face skill and language barriers, are often not qualified to work on large infrastructure projects, and work can be subject to

	2010	2012	Av annual increase (percent)
Gross farm revenue	12,155	14,886	11
Value own consumption	9,907	11,852	10
Value increase in assets	2,198	2,976	18
Value sales	51	59	8
Gross farm expenses	6,089	6,318	2
Net farm income (returns to labor, capital and management)	6,066	8,569	21
Agricultural subsidies	1,086	1,191	5
Proportion of of subsidies in farm income	18 percent	14%	
Off-farm income	7,500	9,00	10
Proportion of off-farm income in total household income	50 percent	47 percent	
Total household income (including off-farm work and subsidies)	14,852	18,960	13

Table 6. Income effects of increasing agricultural and labor prices in Duopozhang, 2010-2012.

(CAEGTibet model calculations)

the vagaries of government projects and stimulus measures (Fischer 2005, Wang 2009). Local officials interviewed said that local economic activity does not support a large rural workforce, for prolonged periods of the year. Fischer (2008) argues that the “subsistence capacity” of Tibetan farmers Tibetan farmers mean that, in general, they are not overly inclined to engage in long-term, low-wage employment.

Another possible factor that is able to be tested through *CAEGTibet* is the clash between peak seasonal labor demands for on- and off-farm work. The demand for labor in construction and transport is highest in warm months and all but shuts down in winter due to cold weather, snow and holidays. Even though farm sizes are small and households have surplus labor on a whole-year basis, much of the surplus occurs in cold months. In summer households struggle to keep up with all their farm work, which may limit opportunities to take advantage of peak labor demand off-farm. This is particularly important as rural families rarely move out to pursue off-farm work permanently, but retain a foothold in agricultural and village activities (Childs et al 2010, Fischer 2010).

Seasonal labor use for household and on-farm work is quantified using *CAEGTibet* and presented in Table 7. Labor use is calculated in the model based on estimated labor requirements (expressed in labor units) per month for all individual activities (for different species of animals, types of crops, livestock and crop processing, off-farm work and general non-agricultural household jobs). Labor use varies from less than 30 person days per month in winter to more than 70 days in summer. This is balanced against household labor availability, based on an average (‘representative’) household for four members, two of which are working age ‘primary labor’ units available to work full-time (60 days per month), while two children and elderly members are aggregated as ‘secondary labor’ units.¹⁸

When household labor demand is balanced against supply, there is a significant labor surplus in winter months (where cold weather precludes cropping activities and animals are penned night and day) and a significant labor deficit in summer when livestock are most active and productive, with the additional labor demands for dairy processing. Labor deficits are addressed mainly through mutual help, barter and hard work. The cost of casual farm labor has increased substantially in recent years to reach up to Rmb50 per day, which few farm households could afford to pay on a cash basis. Households use various labor allocation strategies to free up household members to work off-farm in summer off-farm employment times (see for example Goldstein 2010). In addition, new labor saving

technologies and increased mechanization have transformed labor use, particularly in the busy warm season in both the livestock and cropping sectors (see Childs et al 2010).

Livestock accounts for a large proportion of labor use. Apart from general animal husbandry, large amounts of time are spent especially in summer/autumn for milking and butter and cheese making. As recently as 2011, butter churning was a very labor intensive process requiring around 0.4 person days to make one kilogram of butter. The uptake of mechanical churners since then has reduced the labor requirement to around to 0.1 person days, reducing household labor usage by around three person days per month in the busy period. Grazing, collecting animals for penning, watering, feed preparation and the cut-and-carry of feeds is also labor intensive. To reduce grazing labor, especially for sheep and goats, groups of households combine to pay a full-time herder (who in two cases was cross-subsidized by their job in forest protection). Households with large yak herds commit labor to them nearly all year-round.

Cropping appears in Table 7 to account for a modest proportion of household labor. However cropping requires a large number of occasional activities (weeding, fertilizer, pest control) especially in spring and autumn. Some major cropping activities – planting, manure spreading and harvesting – are done collectively in Duopozhang, often orchestrated by local government. Cultivation and transport has become considerably less time consuming in recent years with the uptake and subsidization of three-wheel tractors (both with steering wheels and handle bars), but many households retain draught cattle out of tradition and for the many small, terraced plots in Duopozhang.

Land Markets

Notionally land use markets allow renting households to increase scale and renters to take up non-farm employment (‘stepping up and stepping out’ of agriculture). Households can and do lease out land use rights in areas like Changzhu Town, a peri-urban of Zedang, where several households had entered into small-scale tourism and transport operations (mainly for the Changzhu Monastery). Their land was rented by neighboring households seeking to specialize in agricultural production and expand their operations. Some marginal cereal crop land in more distant parts of the village is rented out to a few larger livestock households to grow fodder crops. No cases of land rental were encountered in Duopozhang because of the tight supply of land and because families retain their roots, traditions and self-identity in agriculture.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Total labor use (days)	24	25	28	45	74	74	73	47	43	58	50	26
General household labor (percent)	48	44	40	25	15	15	15	24	26	20	23	43
off-farm labor (percent)	0	0	0	0	40	41	41	0	0	17	40	0
cropping labor (percent)	6	6	14	13	4	3	3	13	7	15	6	0
livestock labor (percent)	39	44	41	59	38	38	38	60	63	46	28	51
Utilization of available labor (percent)	38	41	46	74	121	120	120	76	70	94	82	43

Table 7. Key labor use indicators.
(CAEGTibet model results)

Agricultural Services

Facing a limited natural resource base and with only partial engagement with markets, the state has increased the provision of public services in the key areas of agricultural extension, subsidies and finance.

Agricultural Extension

Systems to increase agricultural productivity through the new technologies and practices are very important in an agricultural township like Duopozhang. For example, CAEGTibet simulations suggest that dairy farmers that adopt improved systems (forages and mineral blocks) can have net incomes 42 percent above 'low productivity' systems. However, increasing productivity at scale involves a major shift in the way people live their lives and generate income, which requires ongoing technical, management and social support. The extension system in Duopozhang comprises the following units:

The agricultural machinery repair point which is also in charge of methane converters that have been rolled out widely in Duopozhang;

The village-to-village broadcasting point;

The veterinary and disease prevention station that comprises a formally qualified veterinarian at township level, but which have yet been established at village level. Instead, the township vet oversees less qualified technicians (animal paramedics) in each of the village groups; and

The yellow cattle improvement station, which consists of three 'points' in the township that do artificial insemination for beef and dairy cattle. All technicians and veterinarians are not formally on the state payroll but are paid an annual wage by the government (or collective) of around Rmb750-850.

The shortcomings of agricultural extension systems in Tibet, and indeed throughout China, are widely recognized. Higher-level reforms have filtered through to Duopozhang in recent years through several measures.

To coordinate extension activities, the points and stations above have been consolidated under a new agency called the Agricultural and Livestock Comprehensive Service Centre. The deputy township head leads the Centre, which has jurisdiction over the full range of agricultural and resource areas – agriculture, livestock, forests and water.

Technical envoys (*tepaiyuan*) are allocated or stationed (by the Ministry of Science and Technology) within groups—one for agriculture and one for livestock and that are responsible for collective activities such as pesticide spraying. This system is being wound down.

A *shuangliang* system was established in Duopozhang in 2013, where the township coordinates with between four and six 'lead households' in each village group who then coordinate with around eight households primarily on cropping activities.

Pastoral groups also have a 'forest protection team,' and a designated person to monitor access to forests (for a wage of around Rmb5,000/year) but that also provide herding services for households.

Agricultural Subsidies

As mentioned above, the state provides a range of subsidies to incentivize uptake of targeted technologies and systems. These increased between 2010 and 2015, when township officials calculated that altogether the state provides 24 different types of subsidies. Subsidies amount

to about eighteen percent of on-farm net incomes in 2010, but even with increasing absolute levels of subsidies, the proportion of on-farm net incomes reduced to fourteen percent in 2012 (Table 6). While the role of Duopozhang as a research and development area may mean that these levels are higher than normal, the differences with other areas will be of degree only.

Examples of subsidies include:

Seeds can be provided free to promote particular improved varieties, and subsidies for some crops (canola in recent years).

Fertilizer is bought by the township (from a state-owned enterprise) and distributed to households at a heavily subsidized cost and can be free for poorer households. As a result, fertilizer application rates are high even by Chinese standards of about 470kgs/ha according to official statistics.¹⁹ There are obvious implications for soil quality and structure and the longevity of land cultivation, although this is partly offset by the application of large quantities of manure (one ton per *mu* or fifteen tons per ha).

Agricultural machinery, especially three-wheel tractors for transport and cultivation, can be subsidized, especially if a household belongs to an association. Replacement of draught power from cattle saves farm labor and has changed the role of cattle in crop-livestock systems.

Pesticides, where the Township government spray for pests throughout the township and villages. Individual households were said not to spray correctly or are reluctant to spray in parts of the year where there are amnesties on all life, including pests.

In livestock, artificial insemination, parasite and disease services are provided free. Government subsidizes breeding pigs and insurance (as a national policy) as well as improved cattle (Rmb20 per calf born).

In 2013 the Poverty Alleviation Office, and other departments (country Agricultural and Animal Husbandry departments), established a livestock distribution program. 71 cows, 86 yaks and planned for 1,000 sheep and goats were distributed to 34 households (26 of which were poverty stricken) that are then obliged to return an equivalent number of calves within two years for redistribution to other

households. The subsidy amounts to Rmb8,000 per household and 5-10 dairy cows can increase households incomes by Rmb5,625. Households co-invest in the program especially through investments in pens and feed. This replicates a Heifer International project conducted in Changzhu Township in the early 2000s.

'Reward' payment for adhering to stocking rates on grasslands are discussed above.

Finance

Low surplus production and cash returns from on-farm activities limit the extent to which households can invest on- and off-farm or to meet consumption and immediate household cash needs such as education and health. Traditionally, residents of Duopozhang have had limited access to credit. A branch of the Rural Credit Cooperative had been built in the township center but was not operating in 2013. Some of the richer households have savings accounts in the Agricultural Bank of China in Zedang. When asked, few households said they were eligible for loans due to limited collateral and the transaction costs and risks for banks. However, there has been a concerted program to increase credit provision in recent years. The government has brokered credit based on categories of credit-worthiness (gold, silver, bronze) that sets limits on loan amounts (to maximum of Rmb50,000). Households interviewed used loans to buy tractors, household appliances, and improve housing. The subsidized interest rates can be as low as 1.2 percent per year.

Conclusions

This paper has provided a micro-structuralist analysis of semi-subsistent agricultural systems in central Tibet. Although the nature of the systems may be heuristically understood, the detailed quantitative modelling shows just how finely balanced food production and consumption is. Small surpluses for most grains can be achieved in most years, but most households have small structural deficits for some products (dairy), and in bad years can suffer significant deficits and livestock deaths.

The analysis also quantifies how changes in agricultural systems translates into different forms of household wealth. Increasing food prices have, for example, increased total household wealth in the forms of increased value of own consumption and appreciation of livestock assets. Due to limited sales volumes, however, this has not translated into significantly higher cash incomes, which is an important aspect of the livelihoods and incentives of farm

households. Even with state subsidies, cash will increasingly be required by rural Tibetans to pay for consumer goods, transport, housing, health, education and other goods and services of the modern economy they are integrating into.

This raises the question of sources of growth and cash incomes for the future, and more broadly the role of agriculture in development in Tibet. As noted throughout this paper, there have been a number of bright spots for agriculture in Tibet in recent years. Buoyant food prices relative to general and input prices have boosted incomes. While prices will not continue to increase at the same rate, and indeed begin plateauing in 2014, supply side constraints suggest that bar any extreme events (e.g. a food safety or disease outbreak), large price decreases that might have high negative income effects are unlikely.

After neglect of agriculture for many years and an emphasis on large-scale projects, the state at multiple levels has turned attention to agriculture through local-level infrastructure, agricultural services, subsidies and finance. This may conform to the Chinese “technical approach to development” but in Duopozhang at least these measures were adapted to fit into traditional and household structures. Together with large-scale funding for housing, and subsidies for education and health, the state has perhaps reinforced the “aid economy” (Fischer 2009), but as illustrated in the paper Tibetan households are also responding to market signals such as the move into off-farm and livestock activities.

Perhaps most fundamentally, there are numerous sources of productivity gains in livestock production and crop regimes that can increase food security and generate surpluses to increase cash incomes (Brown and Waldron 2013). Labor demands for agriculture have been reduced through simple technologies (cultivation and butter churning) or organizational initiatives (herding), which frees up labor for other income generating opportunities.

If semi-subsistence agriculture enables Tibetan farmers to be selective about the amount and type of off-farm work they choose to do (Fischer 2008), it might be expected that improved agricultural conditions might make households more selective. For example, higher food prices may provide a disincentive for rural households to move or work in urban areas where they would have higher cash outlays for food. Increasing asset values (livestock) will increase household feelings of wealth. Furthermore, with ready access to markets, livestock can easily be converted into cash should the need arise, which may reduce feelings of household vulnerability. Increased subsidies for education, extension and other social services mean that households

have less immediate need to earn cash off-farm. Higher prices will also divert inputs including labor into activities like livestock which—for some households—will become a specialized, entrepreneurial and profitable activity (Childs et al 2010; Goldstein et al 2010; Brown and Waldron 2013).

While agricultural development might delay the transition off-farm, it is unlikely to halt or reverse it, let alone bring rural incomes in Tibet into parity with the rest of China or with Tibetan urban incomes. Even with favorable conditions, income from agriculture – and especially cash income – are unlikely to meet the needs and aspirations of the bulk of Tibetan rural households across generations into the future. If there are widespread opportunities to work off-farm in the future, and household take into account opportunity costs of labor, small-scale livestock breeding becomes unprofitable (Longworth et al 2001; Brown and Waldron 2013). Tibet will no doubt follow the “iron law of development,” where agriculture plays a diminishing role in GDP and employment (Schultz 1968), but also continue to provide safety nets and “pathways out of poverty” including integration with the off-farm economy (World Bank, 2007). However the pace, scale and nature of the transition will not be linear and will be different to that of ‘inland China,’ forged by macro settings, household structures and social perspectives particular to Tibet.

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Endnotes

1. These included projects funded by the Australian Centre for International Agricultural Research on crop-livestock systems (with a particular emphasis on forages and dairy) and the mineral nutrition of livestock (with implications for human health). The projects were conducted in collaboration with the Tibetan Academy of Agricultural and Animal Sciences. For further information see Paltridge et al (2009), McNeil et al (2014) and Spiegel and Costa (2014).
2. The components form a DPSIR framework that is commonly applied to ecological and social systems (see for example Fisher et al 2013: 1102; Rapport and Friend 1979; Rounsevell et al (2010).
3. There are fifteen *mu* in one hectare.
4. In 2013, the township had plans to build a potato production base of 850 *mu* through contracts with a company from 'inland China' in a 'Develop the West' duikou relationship. Under the arrangement, the company would provide some inputs and purchased outputs at contract prices. However township officials claimed that, beside this, no other specific projects had been carried out in the townships under the 'Develop the West' program.
5. Township data records that 598 person trips were taken to conduct external labor (*laowu shuchu renci*, 2.6 percent more than 2011) generating revenue of Rmb2,422,100 (up 18.3 percent, which suggests increasing labor prices between 2011 and 2012). With 422 households in the township, this means that on average each household conducted 1.4 trips per year, earning Rmb4,050 per trip, for two to three months of work.
6. In Changzhu, an agricultural township on the outskirts of Zedang, interviewed township officials said that 60 percent of household income comes from off-farm work.
7. Income data from 2010 and 2012 are used in this section to enable comparison with township data.
8. For a few days after calving, cows produce colostrum that contains proteins and vitamins essential for normal calf growth and immunity. Traditional practice in Duopozhang (and indeed much of Tibet) has been to divert milk containing colostrum to elderly or sick people in the village, which has questionable effects on human health but that permanently stunts animal growth. Research and extension agencies are seeking to change these practices. In addition, soil in much of Tibet is also deficient in minerals especially Selenium, which is expressed in the severely debilitating Kashin-Beck disease, osteoarthopathy and hypothyroid cretinism. There are comparable effects on livestock. Pathways for inserting different forms of selenium into the food chain (through fertilizer into soil, crops, straw, livestock, livestock products and human consumption) have been explored, and mineral blocks directly for livestock consumption have been trialled and extended in Duopozhang (ACIAR project LPS/2010/028).
9. Most of the serious cases of degradation in China occur in semi-pastoral areas like Duopozhang with dense human and livestock populations and pressure to increase livestock numbers (Brown et al 2008).
10. The state has only recently established household use rights over grasslands and the legal basis for enforcing stocking rates in Tibet. While use rights over grasslands—even summer grasslands—have been established in some pastoral areas of China for decades, these were only established in Duopozhang in November 2011, when households were issued with grassland contracts based on human and livestock populations. Households with five members had useable grassland areas of around 550 *mu* partitioned over a number of grassland areas. Even with the contracts and maps, households do not know or care about individual household boundaries. However, under recent grassland programs, boundaries between groups (collective grazing land) had been clarified and grazed according to group rules. Carrying capacities of the different types of grasslands were established, which sets a stocking limit for households (in terms of sheep equivalents that can be converted to other types of livestock at specified coefficients).
11. Starting from 2002, national policy has continued to apply seasonal and total grazing bans and “compensation payments” to households (see Brown et al 2008) and fencing and enclosure in Tibet (Bauer and Nyima 2010). These measures have not been implemented in Duopozhang where grasslands degradation is not classed as severe. In less degraded areas, under the 2011 “Grassland eco-protection subsidy and reward mechanism”, households are “rewarded” to adhering stocking rates through payments of Rmb1.5 per *mu* on native grasslands and Rmb10 per *mu* on improved grasslands. This commonly adds Rmb800-900 to household incomes. In addition to Duopozhang, the program was implemented in another township in Naidong, namely Suozhu. Participating households in Duopozhang were also eligible for production subsidies (Rmb500 flat subsidy as well for breed improvement and forages).
12. Township data is presented in Table 5 in order to broaden data sources. These estimates broadly align with results from CAEGTibet modelling based on data from surveyed household, and indeed suggest that the estimate of external trade from Duopozhang officials may be overstated. CAEGTibet results are that sales as a proportion of production for the representative household are one percent for winter wheat, minus five percent for spring

barley, 0.1 percent for oilseeds, minus eight percent for roots crops, -41 percent for butter and minus nineteen percent for cheese. Herd increase over the year is 1.8 calves and 8.7 lambs and kids.

13. As a reflection of this, turnoff rates for bovines (number sold as a proportion of number in stock) is 46 percent in China and 21 percent in Tibet (Editorial Board of the China Animal Husbandry Yearbook, 2014).

14. Price data was collected on fieldwork in 2011 and 2013 (and 2015) from households in Duopozhang and from markets and traders in Zedang. Between 2010 and 2012, average annual prices increased by nineteen percent for bovines, eighteen percent for sheep and goats, ten percent for pigs, four percent for poultry, thirteen percent for dairy products, eight percent for wool, hair and eggs, eight percent for grains, ten percent for horticultural products, ten percent for feed, zero percent for fertilisers and pesticides, and ten percent for seeds. The daily wage rate for construction work increased from Rmb50 to Rmb60 over the period, and subsidies increased for cropping items.. Note that income data presented in Table 6 varies to that presented in official township statistics, due to a very large number of different values (e.g yields, production, prices) and valuation methods (e.g. CAEGTibet values grass and straw as an input of livestock production). However, both methods exclude the opportunity cost of own labor (which if included makes the farm commercially unviable).

15. Unlike more intensive agricultural areas in 'inland China,' farmers do not take animals to market to discover prices or sell animals, as low livestock densities make live animal markets unviable. Despite the proximity to Zedang, farmers or farmer groups do not truck livestock to Zedang to sell because of the risks of not being able to sell for their asking price and then incurring truck, holding and feed costs.

16. The collection of "caterpillar fungus" (genus *Cordyceps*) is an important source of off-farm income in summer for many rural households in Tibet (Sulek 2010), but not in Duopozhang.

17. These results are based on the household spending 40 working days per month working off-farm for three summer months, and occasional intermittent work in other months, and an increase in wages from Rmb50 per day in 2010 to Rmb60 in 2012.

18. Model users can specify the order by which labor is utilised for broad activities, for example off-farm labor and corvee labor can only be conducted by primary units, while cropping and livestock is first allocated to primary units and if not available then to secondary units. Thus, the current version of the model is limited in that it does

not disaggregate between other age categories, or by gender, marital status or other distinctions that are relevant in household labor allocation.

19. On a land area of 4,212 *mu* in Duopozhang in 2014, the township distributed 71.1 tons of urea, 36 tons of DAP, 4 tons for potassium chloride and 22 tons of compound fertilizer. It is estimated that 4,057 tons of manure are applied.

References

- Bauer, Kenneth, Geoff Childs, Andrew Fischer, and Sienna Craig. 2010. "Development in Tibet: Land, Labor and Social Policy in a Context of Rapid Transition." *Himalaya, the Journal of the Association for Nepal and Himalayan Studies* 30 (1): 7-8.
- Bauer, Kenneth, and Nyima Yonten. 2010. "Laws and Regulations Impacting the Enclosure Movement on the Tibetan Plateau of China." *Himalaya, the Journal of the Association for Nepal and Himalayan Studies* 30 (1): 23-38.
- Brown, Colin, Scott Waldron, and John Longworth. 2008. *Sustainable Development in China's Western Region: managing people, livestock and grasslands*. Cheltenham: Edward Elgar.
- . 2011. "Specialty products, rural livelihoods and agricultural marketing reforms in China." *China Agricultural Economic Review* 3 (2): 224-242.
- Brown, Colin, and Scott Waldron. 2013. "Agrarian change, agricultural modernization and the modelling of agricultural households in Tibet." *Agricultural Systems* 115 (2013): 83-94.
- Cencetti, Elisa. 2010. "Tibetan Plateau Grassland Protection: Tibetan Herders' Ecological Conception Versus State Policies," *Himalaya, the Journal of the Association for Nepal and Himalayan Studies* 30 (1): 39-50.
- CAEG. 2011. *CAEGTibet Manual*, China Agricultural Economics Group, The University of Queensland, Brisbane. <www.uq.edu.au/agriculture/docs/CAEG/CAEGTibetannual01-01-12.pdf>.
- Childs, Geoff, Melvyn Goldstein, and Puchung Wangdui. 2010. "An Entrepreneurial Transition? Development and Economic Mobility in Rural Tibet." *Himalaya, the Journal of the Association for Nepal and Himalayan Studies* 30 (1): 51-62.
- Childs, Geoff, Melvyn Goldstein, Ben Jiao, and Cynthia Beall. 2005. "Tibetan Fertility Transitions in China and South Asia." *Population and Development Review* 31 (2): 337-349.

- Editorial Board of the China Animal Husbandry Yearbook*. Various years. China Animal Husbandry Yearbook. Beijing: China Agriculture Publishing House.
- Fisher, Janet, Genevieve Patenaude, Patrick Meir, Andrea Nightingale, Mark Rounsevell, Matthew Williams, and Iain Woodhouse. 2013. "Strengthening Conceptual Foundations: Analysing Frameworks for Ecosystem Services and Poverty Alleviation Research." *Global Environmental Change* 23 (5): 1098-1111.
- Fischer, Andrew. 2005. *State Growth and Social Exclusion in Tibet: Challenges of Recent Economic Growth*. Copenhagen: NIAS Press.
- . 2008. "'Population Invasion' versus Urban Exclusion in the Tibetan Areas of Western China." *Population and Development Review* 34 (4): 631-62.
- . 2009. "The Political Economy of Boomerang Aid in China's Tibet." *China Perspectives* 2009 (3): 38-55.
- . 2010. "The Great Transformation of Tibet? Rapid Labor Transitions in Times of Rapid Growth in the Tibet Autonomous Region." *Himalaya, the Journal of the Association for Nepal and Himalayan Studies* 30 (1): 63-78.
- . 2013. *The disempowered development of Tibet in China: a study in the economics of marginalization*. Lanham, Boulder, New York, Toronto and Plymouth; Lexington Books.
- Goldstein, Melvyn, Geoff Childs, Puchung Wangdui. 2010. "Beijing's 'People First' Development Initiative for the Tibet Autonomous Region's Rural Sector—A case study from the Shigatse Area." *The China Journal* 63: 57-75.
- . 2008. "Going for Income in Village Tibet: A longitudinal Analysis of Change and Adaptation, 1997-2007." *Asian Survey* 48 (3): 514-534.
- Goldstein, Melvyn, Ben Jiao, Cynthia Beall, and Phuntsog Tsering. 2003. "Development and Change in Rural Tibet: Problems and Adaptations." *Asian Survey* 43 (5): 758-779
- Fan, Xiaojian (ed). 2007. *Xizang Nongmuye Zengzhang Fangshi Yanjiu Research on methods to grow agricultural and livestock industries in Tibet*. Beijing: China Agricultural Publishing House.
- Levine, Nancy. 1999. "Cattle and the cash economy: Responses to change among Tibetan nomadic pastoralists in Sichuan, China." *Human Organization* 58 (2): 161-172.
- Ma, Rong. 2011. *Population and society in contemporary Tibet*. Hong Kong: Hong Kong University Press.
- McNeill, Annie, John Wilkins, and John Piltz. 2014. *Integrated crop and dairy systems in Tibet Autonomous Region, PR China*. ACIAR Final Reports FR2014-04, Australian Centre for International Agricultural Research, Canberra. <<http://aciarc.gov.au/publication/FR2014-04>>.
- National Bureau of Statistics. Various years. *China Statistical Yearbook*. Beijing: China Statistics Publishing House.
- Paltridge, Nick, Jin Tao, Murray Unkovich., Alessandra Bonamano., Alexandra Gason, Samantha Grover, John Wilkins, Niyima Tashi, and David Coventry. 2009. "Agriculture in central Tibet: an assessment of climate, farming systems, and strategies to boost production." *Crop Pasture Science* 60: 627-639.
- Rapport David, and Anthony Friend. 1979. *Towards a comprehensive framework for environmental statistics: a stress response approach*. Statistics Canada catalogue 11-510. Minister of Supply and Services Canada, Ottawa.
- Rounsevell, Mark, Terence Dawson, and Paula Harrison. 2010. "A conceptual framework to assess the effects of environmental change on ecosystem services." *Biodiversity and Conservation* 19 (10): 2823-42.
- Schultz, Theodore. 1968. *Economic Growth and Agriculture*. New York: MacGraw-Hill.
- Spiegel, Nicole, and Nick Costa. 2014. *Improving the mineral nutrition of Tibetan livestock*. Final Report for LPS/2010/028. Canberra: Australian Centre for International Agricultural Research.
- Sulek, Emilla. 2011. "Disappearing Sheep: The Unexpected Consequences of the Emergence of the Caterpillar Fungus Economy in Golok, Qinghai, China." *Himalaya, the Journal of the Association for Nepal and Himalayan Studies* 30 (1): 9-22.
- Yeh, Emily, and Kunga T. Lama. 2013. "Following the caterpillar fungus: nature, commodity chains, and the place of Tibet in China's uneven geographies." *Social & Cultural Geography* 14 (3): 318-40
- Tibet Bureau of Statistics. Various years. *Tibet Statistical Yearbook*. Beijing: China Statistical Press.
- Tibet Daily. 2009. Tibet to Bolster Agriculture, Animal Husbandry in 2009. *Tibet Daily*, 11th February 2009. <www.chinaview.cn> (20.01.11).
- Waldron, Scott. 2010. *Modernising China's Agriculture: upgrading agrifood chains for beef*. Newcastle upon Tyne: Cambridge Scholars Publishing.
- Wang, Shiyong. 2009. "Policy impact on Tibetan market participation." *Asian Ethnicity* 10 (1): 1-18.
- World Bank. (2007). *World Development Report 2008: Agriculture for Development*. Washington DC: World Bank.