Southern Tibet Human Activities: Ecological Footprint Analysis of Nyingchi Region

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Abstract: The Tibetan Plateau has experienced a series of environmental changes in the last century due to climate change and anthropogenic activities. Extensive studies have examined the effect of anthropogenic activity disturbances such as grazing and transhumant pastoralism on the ecosystem of the TP. However, there remains much to learn about the impacts of forest economies in the less studied Southern TP region. This paper intends to evaluate the impacts of human actives in the forest region on the TP by focusing on a village (Nyingchi) in the above-mentioned region. Our study aims to carry out a full set of human footprint analysis that includes carbon, water, energy, and land-use footprint of the region through fieldwork, interviews, and onsite monitoring. The current paper presents a research plan with preliminary results that includes fieldwork analysis and preliminary calculations. Our current analysis indicates the need for future research on human footprint analysis in the southern TP region, with special attention to mapping the region's spatiotemporal patterns from high-resolution data by using bottom-up analysis.

1 INTRODUCTION

The Tibetan Plateau is the world's largest land unit with the highest elevation. As the world's "Third Pole", it plays central roles in mediating climate change as well as other important ecological services, such as water reservoir, regional climate regulation, promoting rich biodiversity (Jiang et al., 2020). In recent decades, however, the Tibetan Plateau has experienced a series of significant environmental changes such as degrading grassland, melting glaciers increasing precipitation (Duan & Wu, 2006). It has been acknowledged that these environmental changes in the Tibetan region in the last few centuries have been altered by not only climate change, but also human activities, such as grazing, felling, farming, urbanization (Gao et al., 2013). As the fragile ecosystem of the Tibetan region is extremely vulnerable to disturbances, minor anthropogenic disruption can have a serious environmental influence on the region.

Extensive studies have been carried out examining the effect of anthropogenic activity disturbances such as grazing and transhumant pastoralism on the ecosystem of the alpine grassland region of the Tibetan Plateau (Fan et al., 2015; Zhao et al., 2015). These abundant studies have demonstrated the high interest of the academic community in the TP region. However, compared with the attention directed to pastoral activities on the TP, other forms of anthropogenic activities and economy types have been largely neglected and

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discussed much less extensively in existing studies, such as the subsistence forestry economy in Southeastern Tibet. While the alpine forest landscape and forest economy are much less typical and dominant in the TP region, the Southern TP forest region plays crucial roles in carbon sequestering, water reserving, as well as represents one of the most bio-diversified area in the world (Shen et al., 2015).

Human activities in this region largely scatter across the shrubland and forest area along the middle and lower reaches of the Yarlung Tsangpo River Valley. Historically, this area has been one of the most isolated regions in the world, with villagers living in almost primitive states until the late twentieth century. However, in recent decades, as urbanization and tourism brought alteration to the human-environment dynamic in the TP region, this region has experienced major socio-economic changes, characterized by the increase of population, increased income, booming tourism, and more active residential migration (Sheehy et al., 2006). This proportionally small region has now become important economically important in the TP region, therefore, more studies are necessary to further our understanding of the human impact in this region which exhibits both significant environmental and socio-economic changes.

The aim of this study is to map out the human footprint in subsistence forestry economies in the southern TP region by focusing on a village (Nyingchi) in this area. This study intends to collect data from onsite monitoring of greenhouse gas emissions, including CO2, CH4, and N2O fluxes in the soil and air, as well as water, energy, and land use data. A detailed inventory list of assets and expenditures is projected to be obtained through semi-structured interviews of the local inhabitants. After these data are obtained, a unified set of accounting frameworks will be adopted to calculate the living footprint of the region, including input-output analysis, life cycle analysis, systems process analysis, etc. This paper presents the research plan as well as preliminary results of the present project. The rest of this paper is organized as follows: Section 2 presents the methodology and study area of this project; Section 3 presents the preliminary fieldwork results, Section 4 presents preliminary calculation results, and the last section presents discussions and conclusions.

2 METHODOLOGY

2.1 Accounting Framework

A full set of accounting frameworks will be used to calculate the living footprints of the region, including top-down approach such as systems input-output analysis, bottom-up approach such as life cycle analysis, and systems process analysis. For these assessments, we first track the inputs of a production unit in a step-by-step manner to a level where the input items match the sectors in the input-output tables, after which match the results with the intensity databases that are generated from systems input-output analysis. The assessments require systematic accounting framework that allows for coherent processing of large amount of data, as well as detailed inventory data to an extremely high resolution of family units. Details for these series of accounting methods can be found in our previous studies (Chen et al., 2013, 2019; Wu et al., 2021).

2.2 Fieldwork

The project intends to conduct field monitoring of greenhouse gas emissions, water, energy, and land use in the region so as to build a resource use inventory.

Multiple sampling points will be set up in the region. Static camera obscura-gas chromatography as well as standard sampling boxes (50cm × 50cm × 50cm for the tank and extended box and 20cm × 50cm × 50cm for the chassis) will be used to collect fluxes of gas. After the gases are collected, they will be shipped to laboratory for examination using Agilent 4890 gas chromatograph. Specimen such as yak dung will also be taken as samples to laboratories for testing.

2.3 Interviews

To gain data in family-production-unit resolution, this project intends to interview the majority of families in the study area by using structured and semi-structured interviews. So far, we have carried out interviews in August 2019 and August 2020. Questions about the villagers' production activities, material, and monetary assets, household expenditures, as well as cultural and festival activities (which can take up a significant proportion of living footprints in the area) were asked. Interviews were carried out in the local language (Tibetan), and then translated into Mandarin. All interviews were recorded and videoed after informal consent by the interviewees, which are then entirely transcribed

(disclosed upon completion of the project). Typical questions include: “What are your family incomes?” “What does the income source of the family comprise of?”, “What are the housing arrangements? Is housing subsidized by the government?”, “How many family members are there in the family?”, “How are the pastureland/forestland/arable land allocated? How many acres do each family own?”, “How many livestock (including yak, chicken, pigs, etc.) does your family own?”, “What are the festival activities in the region and what are the social customs?”, etc.

2.4 Study Area

Nyingchi is located at around 26°52′N ~ 30°40′N, 92°09′E ~ 98°47′E, southern Tibetan Plateau. It lies at the abrupt hairpin turn of the Yarlung-Tsangpo river, at the foot of the Namjagbarwa Mountain. The region covers an area of around 117 thousand sq km with an altitude ranging from 150m above sea level to over 7000 m asl, with an average elevation of around 3000 meters. Due to the high altitude drop in the region, this region possesses the most complex vertical-belt distribution in the world. Nyingchi is characterized by abundant forest and shrub vegetation, hosting a forest area that covers 26.4 billion cubic meters, with over 3500 species of higher plants and 123 types of wildlife species in the region. Figure 1. shows series of photos taken in the study area.

Nyingchi is home to a variety of minority ethnic groups. Having a population of around 2.3 million until 2016, its ethnic race mainly consists of Tibetans, Menba, Luoba, Nu, Dulong, Naxi, Bai, Lisu, and Yi. This unique ethnic combination has shaped both the culture and production activities in Nyingchi region, as can be seen in our next section.

a) Yarlung Tsangpo River Valley

b) Entrance of Nyingchi village

c, d) Inside the primordial forest of Nyingchi region, near Nyingchi village

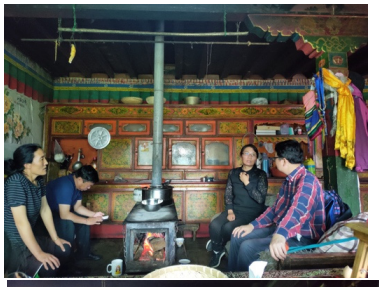
Figure 1. Photos of Nyingchi region.

3 PRELIMINARY RESULTS

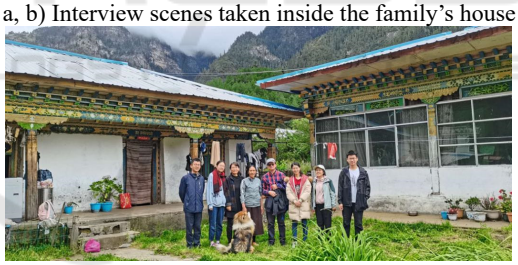
Here we show preliminary results obtained from some of the interviews. We observe drastically different living styles in Nyingchi from the northern

traditional pastoral region of Tibet, where a nomadic lifestyle is led in the arduous conditions of the highland. Nyingchi region is well ecologically endowed, leaving its inhabitants with rich living materials. The production patterns in Nyingchi are similar to a self-sufficient farming economy, with a focus on the cultivation of arable land, along with extensive use of natural endowments in the mountains and rivers, such as mining valuable precious medical materials for trade. The fertile land and warm climate as well as the rich forest and biotic resources allow the local inhabitants relative well-off living conditions, comparably better than a typical inland Chinese farmer, due to the agreeable climatic conditions for farming and extra tourism dividends. The food abundance is shown to be extremely high, with suitable conditions for raising a variety of livestock (cow, yak, pig, chicken, duck, sheep, goat, etc.), fertile black soil for growing crops and vegetables, and rich biotic resource in the nearby forest for spice, seasoning, fungus, medicines, as well as other wild food sources. This is in great contrast to the northern pastoral region of Tibet where only yak and goats are the available source of food. Housing is provided by the government in the region, with an architectural appearance similar to traditional Chinese cottages with Tibetan decorations. The major energy source in the region consists of firewood collected from the forest, hydropower from traditional hydropower stations, and modern power grids. Cow and yak dung are also collected for burning. Primary and secondary education is provided by the local government free of charge, living expenses such as meals in canteens are provided to students in the form of subsidies. Additionally, we find phone service generally take up a significant proportion of the expenses in the area, sometimes accounting for around 15% of the total expenses.

The following content provides the income, asset, and expenditure list for an interviewed family of three, including husband, wife, and son (two married daughters not taken into account)(table 1.). Salary income from part-time jobs as truck driver and cement worker is the main source of income for the family, taking up more than half of the total income (approximately 53.7%). Income from the tourism industry also takes up a significant share of the total income (approximately 43.0%), including selling food to tourists (32.2%) and dividends from tourist attraction ticket fees (10.7%). Pastureland subsidies are also provided to families, depending on the acres of pastureland that is contracted to the family. The conventional major expenses of a family such as housing and food expenses are almost null, with the former covered by the government and the latter self-sufficient (from self-owned cultivated-land and livestock). The major expenses for the interviewed family include education, phone service, and clothing, each taking up 74.9%, 14.9%, and 6.2% of the total expenses, respectively. The physical asset of the family includes housing provided by the government, arable land in the back yard of the house, and livestock (15 cows, 10 pigs, 60 chickens).



a, b) Interview scenes taken inside the family's house



c) Photo of interviewee and research group in front of the family house

Figure 2. Photos of a selected interviewed family in Nyingchi.

Table 1. Income, asset, and expenditure list for an interviewed family of 3.

Income	
Ticket from tourism	10000RMB/year
Pastureland subsidy	3000RMB/year
Selling potatoes, fish, tea to tourists	30000RMB/year
Income from part-time job (husband)	50000RMB/year (truck driver and cement worker)

Assets	
House	approximately 100 sq m (provided by the government)
Arable land	approximately 500 sq m
Cows	15/year
Pigs	10/year
Chicken	60/year
Expenditure	
Housing	0
Food	0 (self-sufficient)
Electricity bill	556RMB/year
Clothes	2000RMB/year
College education (enrollment fee)	700RMB/year
College education (living expenses)	24000RMB/year
Phone service	4800RMB/year

4 PRODUCTION INTENSITIES OF THE REGION

We plan on obtaining production intensity of arable land, pastureland, water use, energy use, and carbon emissions in the Tibetan region of 42 economic sectors. After obtaining a detailed inventory list of emissions water use, land use, and energy use in the region, a systematic analysis of the series of footprints in the region can be calculated. However, current production intensity calculated from official Tibetan statistic input-output data may suffer from sectoral and regional aggregation, which point to the need for more detailed fieldwork analysis of production efficiencies in local regions.

5 DISCUSSIONS AND CONCLUSIONS

Preliminary interviews and fieldwork of this study have shown that the ecological footprints are considerably small compared with inland regions. The investigation of the village has shown that the production patterns of the Nyingchi region is similar to a combination of subsistence forest economy and small-scale farm economy, with a large proportion of the daily necessities harvested in a self-sufficient manner. With the current data and fieldwork setup, this study plans to make further progressions in the following area:

First, face-to-face semi-structured interviews with the villagers in the Nyingchi area need to be carried out to collect more data on the living expenditures and incomes of families. The field study plans to apply the snowball sampling method that aims to survey at least 50 more participants to acquire needed data to be incorporated in the full set of evaluation models that has been developed.

Continue field monitoring of greenhouse gas emissions in already established points in the Nyingchi Region, and deploy more sampling points of water use, land use, and energy use in the region to build a comprehensive emissions inventory of the region's GHG emissions and other resource use.

A full set of evaluation systems that consist of standard procedures to analyze the multi-scale living footprints of residents in Tibet will then be applied.

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