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Ecological and Environmental Issues Faced by a Developing Tibet

Chengqun Yu,[†] Yangjian Zhang,*[,†] Holzapfel Claus,[‡] Rong Zeng,[†] Xianzhou Zhang,[†] and Jingsheng Wang[†]

[†]Key Laboratory of Ecosystem Network Observation and Modelling, Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences, Beijing 100101, China

[‡]Department of Biological Sciences, Rutgers University, Newark, New Jersey 07102, United States

The Tibetan plateau, covering an area of 2.6 million km^2 with an average elevation of over 4000 m, often called "the third pole of the world", has fundamental significance to the environment of China, Asia, and the world. The Tibetan plateau is called a "water tower" due to its downstream influence on approximately 40% of the world's population. It is a region with rich species diversity and a high-altitude plateau biodiversity conservation base site, where some ancient species were preserved and new species evolved under the unique geology development process. In recent years, a series of ecological and environmental issues have emerged due to enhanced anthropogenic disturbances and climatic change. These issues are gradually eroding the capacity of the Tibet plateau to act as an "ecological security barrier" of atmosphere circulation and water sources for China and southern Asia. This study critically reviews several imminent ecological and environmental issues faced by Tibet and has the goal of drawing the attention of governments and international societies.

The effects of global warming are more obvious in Tibet than in other areas at similar latitude. The temperature in Tibet has been increasing at a faster rate than other inland areas of China in the past decades.[1] Precipitation exhibited no obvious trend, but has occurred in a more concentrated way during each year.

The permafrost soil of Tibet historically covered an area of 1,401,000 km^2, accounting for 54.3% of Tibetan plateau.[2] In the past 30 years, the lower altitude limit of permafrost in Tibet has moved up on average 50 m. The thickness of the active soil layer has increased by 0.15−0.5 m in the past decade. It is projected that the permafrost soil on Tibet plateau will shrink 58% by 2089. Permafrost soil thawing would change soil moisture and the water-holding capacity of soil, which in turn will affect ecosystem primary production.

From 1990 to 2006, the area of wetland on the Tibetan plateau shrank by 6937 km^2. The landscape connectivity between each wetland patch has decreased.[3] From 1980s to 2002, Tibetan glacier has shrunk by 3941 km^2 at a rate of 131.4 km^2/year to 46,887 km^2.[4]

Soils on Tibet plateau are relatively newly formed compared to soils worldwide and are chiefly coarsely textured. This in addition to being windy, arid, and sparsely covered by vegetation, especially in northern Tibet, make the Tibet plateau especially vulnerable to soil erosion, landslides, and sandstorms. By early 2000, 20% of Tibet plateau was desertified.[4] The perturbations are related to even larger scale phenomena, as the frequent sandstorms in northeast Asia were found to have linkage to the expanded desertification in Tibet.

Vast areas of the Tibetan plateau, though at extreme altitude, are relatively level and lack steep slope gradients and slope heterogeneity typical for alpine areas. These high-altitude tundra regions (rather than alpine tundra) of the Tibetan plateau are therefore not characterized by distinct and narrow vegetation belts and fragmented habitat distributions that are found in typical mountain ranges worldwide. Being on "the roof of the world", this geomorphologic peculiarity of the Tibetan plateau makes its biotic communities especially vulnerable to global warming. Whereas narrow altitudinal vegetation belts in mountainous regions might allow plant communities and their constituents to migrate upward over relative short distances with raising temperatures, such movements are only a very limited possibility in a high-plateau situation. The vegetation of the Tibetan Plateau is therefore more similar to the arctic tundra, a biome that is recognized as imperiled due to warming. Unlike the tundra biome, and similar to alpine environments, however, the Tibetan plateau is additionally vulnerable to warming due to vertical constrains.

The population in the Xizang autonomous region in the core of Tibet plateau, covering an area of 1.2 millions of km^2, has been increasing at a much faster rate than other inland areas of China. Even a small increase might bring about amplified effects due to low support capacity under extreme conditions typical for Tibet. In 1990, the total population in Xizang was 2,210,000, and increased to 3,002,100 in 2010. The number of tourists increased from 3530 in 1980 to 6,851,400 in 2010. By

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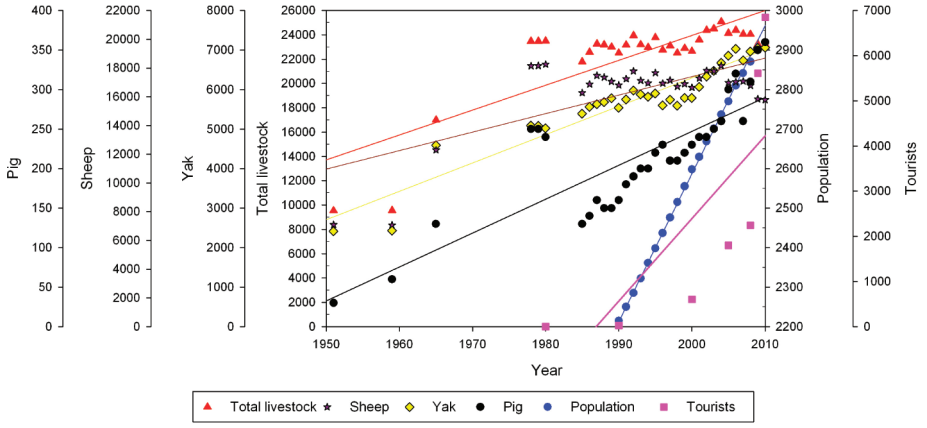

Figure 1. Population growth, livestock growth, tourist growth (unit: thousand). Note: The total livestock number is the sum of pig, sheep, and yak. In calculating grassland supporting capacity, big animals, such as yak, will be transformed into standardized sheep unit as one yak = five sheep.

2010, the total road length was 58,249 km, a growth of 4404 km from 2009 (Figure 1).

From 1951, the total number of livestock in XiZang increased from 9,550,000 to 23,490,000 in 2010, equal to 51,090,000 units of sheep (Figure 1), which is 89.4% higher than the estimated support capacity of the XiZang grassland.[5] Consequently, 114,300km^2 of the grassland has been degrading in the 1990s, which accounts for 17.2% of XiZang grassland, among which 57% is lightly degraded, 32% is intermediately degraded, and 16% is intensively degraded.

In recovering and protecting ecological environment of Tibet, the most commonly used measurement taken by government is fenced grazing. However, its limitation lies in that most grassland systems have in fact evolved over time as grazed ecosystems, originally with wild and increasingly by domestic grazers. Because of this it remains untested whether a respite from livestock grazing can restore grassland to its natural state. In nature reserve areas, the protected populations of Tibetan antelope (*Pantholops hodgsoni*) and wild yak (*Bos grunniens*) have been increasing rapidly, but their predator populations are still lacking behind. Increasing numbers of large wild herbivores due to human protection need to consume a greater amount of the primary production and potentially overstep the limits of the pastures. In addition, local herders, bound by traditional values, prefer to invest their compensation distributed by the government in the "rangeland to grassland" program in more livestock rather than changing to other careers, and the goal of downsizing livestock is not achieved.

Overall, we cannot afford to overlook the series of ecological and environmental problems faced by an economically developing Tibet. To resolve these issues, a comprehensive set of measures including controlling rural population growth, encouraging herdsmen to relocate to urban areas, and improving their education level are recommended.

AUTHOR INFORMATION

Corresponding Author

*E-mail:zhangyj@igsnrr.ac.cn; phone: 08816-1064889703.

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