From the Tibetan Plateau to the Third Pole and the Pan-Third Pole Postprint

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Abstract

The Tibetan Plateau serves as a critical environmental and ecological barrier for the living environment and sustainable development of China, Asia, and even the entire Northern Hemisphere. The Third Pole, centered on the Tibetan Plateau, and the Pan-Third Pole regions it influences—including East Asia, South Asia, Central Asia, West Asia, and Central and Eastern Europe—span an area of over 20 million square kilometers, encompassing more than 3 billion people across over 20 countries. This region constitutes the core zone of the "Belt and Road" initiative and the most densely populated area globally. As this major initiative progresses, the significance of environmental changes in the Pan-Third Pole region has attracted worldwide attention. The region is already confronting serious resource and environmental issues, and protecting the sustainability of its resources and environment represents a major challenge for implementing the "Belt and Road" construction. The special project on "Pan-Third Pole Environmental Change and Green Silk Road Construction" will conduct in-depth research on resource and environmental scientific issues in this region at regional and even global scales, prospectively and scientifically propose collaborative response strategies for regional sustainable development, and serve the dual goals of "safeguarding the last pure land on Earth" and advancing the "Belt and Road" initiative.

Full Text

Preamble

This special issue on "Progress of Comprehensive Scientific Research on the Tibetan Plateau" is published in collaboration with ChinaXiv. The Pan-Third Pole region, centered on the Tibetan Plateau, substantially overlaps with the Silk Road Economic Belt. Against the backdrop of the Belt and Road Initiative, achieving regional development while "safeguarding the last pure land on

Earth" requires a foundation of scientific research and multidisciplinary understanding of the plateau' s geology, ecology, and human dimensions. Since its founding, the Chinese Academy of Sciences (CAS) has been the principal force in Tibetan Plateau research. For over 60 years since the first comprehensive scientific expedition, CAS has continuously conducted multidisciplinary research on the plateau.

In anticipation of China' s second comprehensive scientific expedition on the Tibetan Plateau, this special issue presents the latest research advances across multiple dimensions: the significance of comprehensive scientific expeditions, conservation and development of the plateau, its geological "growth history" (terrane origins and tectonic movements and their impacts on climate and environment), its influence on Quaternary Ice Age fauna and human civilization, and the impacts of natural and anthropogenic environmental changes. This issue aims to provide readers with a comprehensive scientific portrait of the plateau. The special issue is guided by Academician Yao Tandong and Academician Chen Fahu from the Institute of Tibetan Plateau Research, CAS, and Researcher Ge Quansheng from the Institute of Geographic Sciences and Natural Resources Research, CAS.

From Tibetan Plateau to Third Pole and Pan-Third Pole

The Tibetan Plateau, known as the "roof of the world" and Asia' s water tower, represents Earth' s Third Pole and serves as a critical ecological security barrier and strategic resource reserve for China [1]. As the core region of the Third Pole, the plateau is experiencing the most intense global warming and represents the region with greatest uncertainty regarding future climate change impacts [2,3]. Extending westward from the Third Pole, the Pan-Third Pole region encompasses the Tibetan Plateau, Pamir, Hindu Kush, Tianshan, Iranian Plateau, Caucasus, and Carpathian Mountains—covering over 20 million square kilometers and affecting the survival and development environment of more than 3 billion people. This region forms the core area of the Belt and Road Initiative and represents Earth' s most ecologically fragile zone with the most intense human activity. As the Belt and Road Initiative advances, environmental changes in the Pan-Third Pole have attracted global attention, and protecting the sustainability of its resources and environment will provide crucial scientific support for the initiative [4].

Significance of Tibetan Plateau Research

The Tibetan Plateau is Earth' s most unique geological-geographical-ecological unit and a natural laboratory for studying Earth and life evolution, interactions among spheres, and human-environment relationships [1,5]. As the youngest and highest plateau on Earth, it extends from the Pamir and Hindu Kush in the west to the Hengduan Mountains in the east, and from the Kunlun and Qilian Mountains in the north to the Himalayas in the south, with an average elevation exceeding 4,000 meters (Figure 1 [FIGURE:1]). The plateau serves as a critical ecological security barrier for China' s climate system stability, water supply, biodiversity conservation, and carbon balance [1,6], functioning as Asia' s glacial center and "water tower" and as a regulator of environmental change across Asia and the Northern Hemisphere [5,6].

The uplift of the Tibetan Plateau has profoundly influenced global climate systems by diverting westerly flows and "amplifying" land-sea thermal contrasts that strengthen the Asian summer monsoon, thereby altering Earth' s planetary wind system [7]. This has enabled East and South Asia to avoid the desert landscapes seen in North Africa and Central Asia, instead becoming a crucial climate stability barrier for China and Southeast Asia [8,9]. The plateau' s uplift created the headwaters of Asia' s major rivers—the Yangtze, Yellow, Ganges, and Indus—nurturing civilizations such as Mesopotamian, Indian, and Chinese cultures that have benefited Asian populations. The uplift has also critically influenced biosphere evolution, creating conditions for species origination, differentiation, and global dispersal [10,11], making the plateau a global center for montane species formation, differentiation, and distribution [5,12]. As the largest glacial center outside the polar regions [6], the plateau' s cryosphere dynamics significantly impact regional environments and ecosystems while affecting global sea level changes. The uplift has also generated active tectonic deformation, steep terrain, and intense seismic activity [13], while the plateau' s sensitivity to climate change and increasing extreme weather events have led to frequent natural disasters [14]. Furthermore, the uplift has established the plateau as a strategic resource reserve, with copper, chromium, cobalt, lead, and zinc deposits accounting for 30–80% of China' s total reserves, and gold, platinum group elements, and rare earth elements representing half of national reserves [15]. The uplift has controlled sedimentation, trap formation, and hydrocarbon migration in basins across western China, including the Tarim and Qaidam Basins, with most of China' s proven oil reserves closely related to the plateau' s uplift process [16].

Therefore, studying environmental changes, sphere interactions, disaster effects, and resource implications of the Tibetan Plateau represents both a major scientific proposition and a critical strategic need for regional ecological security, human survival environments, and socioeconomic development.

Tibetan Plateau Research as a National Strategic Task

Since the founding of the People' s Republic of China, Tibetan Plateau research has been a national strategic priority. In the 1950s, China' s 1956–1967 National Science and Technology Development Plan included Tibetan Plateau research as a key component. Despite the Cultural Revolution' s impact, important progress was achieved during the 1963–1972 plan implementation [17,18]. In 1971, Premier Zhou Enlai presided over the National Science and Technology Work Conference, emphasizing the importance of basic theoretical research. As the national science and technology planning authority, CAS organized experts to develop the "CAS Comprehensive Scientific Expedition Plan for the Tibetan

Plateau (1973–1980)" and established the CAS Comprehensive Scientific Expedition Team to the Tibetan Plateau, launching the first comprehensive scientific expedition [18].

The central mission of the first comprehensive scientific expedition was to elucidate the plateau' s geological development history and uplift mechanisms, analyze environmental and human activity impacts following the uplift, and study natural conditions and resource characteristics along with their utilization and transformation pathways. The expedition mobilized over 2,000 researchers across diverse fields including glaciology, permafrost, rivers, lakes, forests, grasslands, soils, land use, ornithology, ichthyology, mammalogy, herpetology, entomology, agriculture, geophysics, geological structures, paleontology, geothermal energy, and salt lakes [19].

To promote international collaboration, the first "International Symposium on the Tibetan Plateau" was held in Beijing in 1980, with Chinese leaders including Deng Xiaoping meeting participating scientists. This high-level national attention greatly inspired researchers to dedicate themselves to plateau science. Subsequently, from 1981 to 1992, the CAS expedition team conducted investigations in the Hengduan Mountains, Namcha Barwa, Karakoram, Kunlun Mountains, and Hoh Xil, completing comprehensive scientific research across 2.5 million square kilometers. The first expedition produced 87 monographs and 5 proceedings, preliminarily exploring plateau formation, evolution, and resource-environment theories, providing scientific foundations for plateau economic development [19]. These achievements earned the CAS Science and Technology Progress Award (Special Prize), the National Natural Science Award (First Class), and the Tan Kah Kee Earth Science Award, with participants Liu Dongsheng and Wu Zhengyi receiving the State Supreme Science and Technology Award[1]. Over 20 expedition members were later elected as CAS or Chinese Academy of Engineering academicians.

In the 1990s, Tibetan Plateau research was incorporated into three major programs: the "Eight-Five" National Climbing Program "Tibetan Plateau Formation, Evolution, Environmental Change and Ecosystem Research" (1992–1996), the "Nine-Five" Climbing Program "Tibetan Plateau Formation, Evolution and Environmental Resource Effects" (1997–2000), and the National Key Basic Research Program "Tibetan Plateau Formation, Evolution and Environmental Resource Effects"(1999-2003) [19]. Compared with pre-1980s research, these programs emphasized quantitative over qualitative approaches, dynamic processes over static studies, integrated multidisciplinary research over single-discipline investigations, and connections with global environmental change over regional studies alone.

In 2003, under the care of then-Premier Li Lanqing, the Institute of Tibetan Plateau Research (ITP) was established to specialize in plateau science. In 2014, the CAS Center for Excellence in Tibetan Plateau Earth Sciences was founded. As China' s leading force in plateau research, ITP and the Center completed the "Scientific Assessment of Tibetan Plateau Environmental Changes," which received high praise from President Xi Jinping at the Sixth Central Tibet Work Conference and served as an important scientific foundation for ecological civilization construction directives. With CAS support, the "Third Pole Environment (TPE)" international program was launched, advancing China' s Tibetan Plateau research into the international forefront [20].

President Xi Jinping has emphasized the importance of plateau ecological protection and development, calling to "safeguard the last pure land on Earth" [21]. To implement this vision, CAS and the Tibet Autonomous Region signed a new strategic cooperation agreement in March 2017, designating ITP to lead the second comprehensive scientific expedition on the Tibetan Plateau. This second expedition will reveal environmental change processes and mechanisms over the past 50 years and their societal impacts, predict uncertainties in regional Earth system behavior, assess resource-environment carrying capacity and disaster risks, and propose scientific solutions for Asian water tower and ecological barrier protection, Third Pole national park construction, and green development pathways to serve ecological civilization and the Belt and Road Initiative.

On August 19, 2017, as the second expedition commenced, President Xi Jinping sent a congratulatory letter with important directives [22]. With strategic vision and global perspective, he elaborated on the significance of plateau environmental change research in global ecological contexts, requiring the expedition to reveal environmental change mechanisms and optimize ecological security barrier systems. He encouraged participants to carry forward the spirit of previous generations—hard work, unity, and peak-climbing—to make new contributions to safeguarding the last pure land and building a beautiful plateau. This fully embodies the ecological civilization and green development concepts of the Party Central Committee, providing direction and fundamental guidance for the expedition. Vice Premier Liu Yandong read President Xi' s letter at the launch ceremony and emphasized that the second expedition should serve national ecological civilization construction, strengthen coordination and collaborative innovation, emphasize integrated interdisciplinary research, and maintain international cooperation to achieve major breakthroughs.

From Tibetan Plateau to Pan-Third Pole: Serving the Belt and Road Initiative

The Belt and Road Initiative represents China' s new-era strategy for optimizing reform and opening-up. During implementation, addressing regional ecological civilization construction and resource-environment issues is urgently needed. The joint vision document issued by the National Development and Reform Commission, Ministry of Foreign Affairs, and Ministry of Commerce emphasizes ecological civilization concepts, environmental protection, biodiversity conservation, and climate change response to build a "Green Silk Road" [23]. On August 17, 2016, President Xi Jinping called for building a green Silk Road with enhanced risk prevention and control capabilities, focusing on key regions, countries, and projects while strengthening academic research, theoretical support, and discourse system development [24]. The May 15, 2017 Belt and Road Forum Roundtable Summit Joint Communiqué established scientific action goals for resource-environment fields, including environmental protection, biodiversity conservation, natural resource management, climate change response, and disaster risk reduction [25].

Geographically, the Belt and Road core area extends westward from the Tibetan Plateau-centered Third Pole to encompass the Pan-Third Pole region including the Pamir, Hindu Kush, Tianshan, Iranian Plateau, Caucasus, and Carpathian Mountains (Figure 2 [FIGURE:2]). The Pan-Third Pole includes over 20 countries and regions—China, Nepal, India, Bhutan, Pakistan, Afghanistan, Bangladesh, Myanmar, Sri Lanka, Tajikistan, Kyrgyzstan, Uzbekistan, Kazakhstan, Turkmenistan, Iran, and others—covering over 20 million square kilometers and more than 3 billion people, coinciding substantially with the Silk Road Economic Belt.

As research deepens and Belt and Road construction advances, Pan-Third Pole environmental change has attracted global attention. Currently, major environmental changes are occurring, with interactions between westerlies and the Indian monsoon driving these changes and extraordinary climate warming amplifying them. Historically, the Pan-Third Pole has warmed at twice the global average rate [2], and under the Paris Agreement' s 2°C warming limit, this region could experience temperature increases up to 4°C. Such dramatic changes create significant uncertainty about consequences for ecosystems and human activities. Climate warming has caused glacier retreat, lake expansion, glacial lake outbursts, and frequent flooding in the Asian water tower region, posing serious threats to socioeconomic development along Belt and Road routes. Meanwhile, glacial meltwater is crucial for water resources [6,27], but glacier retreat in the Tianshan region exceeds global averages, altering water cycles and jeopardizing the future of desert oases in downstream Central Asian lake regions [26]. Desertification and other surface processes are worsening ecological conditions [27], with four of the six Belt and Road economic corridors facing severe desertification threats. Human-emitted PM2.5 combined with special dust storm processes creates the world' s greatest environmental and health threat, with the most severe PM2.5 pollution zone extending from Central Asian deserts through the Pan-Third Pole to eastern China [28]. These rapid environmental changes and intensifying human activities, superimposed on special regional processes, create enormous uncertainty for future resource-environment conditions.

Therefore, in-depth research on Pan-Third Pole resource-environment change patterns and driving mechanisms is needed to scientifically project future trends and provide scientific foundations and decision support for sustainable development of the most densely populated Silk Road Economic Belt.

Chinese Scientists' Foundation and Advantages in Pan-Third Pole Research

The "Pan-Third Pole Environment Change Study for Green Silk Road Development" (Pan-TPE) special project represents a deepening of the TPE international program and a new mission serving the Belt and Road Initiative. The TPE program was initiated in 2009 by CAS Academician Yao Tandong with US National Academy of Sciences member Lonnie Thompson and German Academy of Sciences member Volker Mosbrugger, becoming a UNESCO-UNEP-SCOPE flagship program in 2011 [29]. Led by Chinese scientists, TPE organized over 30 research institutions from more than 10 neighboring Third Pole countries with geographical advantages and over 20 institutions from more than 10 Western countries with knowledge and technical strengths. TPE established an international flagship observation network and data sharing platform with centers in Beijing, Nepal, the US, Sweden, and Germany, conducted multinational joint expeditions, organized senior expert forums and sessions at AGU and EGU meetings, and implemented talent development programs including summer schools and international student training. These efforts have cultivated young scientific and management talent in Belt and Road countries including Nepal, Pakistan, Tajikistan, Uzbekistan, and Iran who understand, appreciate, and support China. TPE has produced over 20 top 1% highly cited papers and internationally influential scientists, with 12 selected as Elsevier 2016 Chinese Highly Cited Scholars and Academician Yao Tandong receiving the 2017 Vega Medal. TPE has propelled China' s Tibetan Plateau research into the international forefront and established an international scientific brand [20,29], providing a solid foundation for Pan-TPE implementation.

Pan-TPE is positioned to serve national strategies for green Belt and Road development and ecological protection of the "last pure land," focusing on environmental change impacts and sustainable resource use through integrated basic research, applied research, technology demonstration, and decision support. Centered on Belt and Road needs and based on climate change and surface processes, Pan-TPE focuses on water, ecology, and human activities, studying environmental change patterns and mechanisms under westerly-monsoon interactions. It addresses key regions, projects, and countries to solve problems in resource-environment carrying capacity, disaster risk, and green development pathways, thereby enhancing risk prevention capabilities, building a green Silk Road, and leading international scientific frontiers and discourse. Pan-TPE targets two overarching scientific questions: (1) how environmental changes under natural and human influences affect green Silk Road sustainability, and (2) environmental uncertainties in the Pan-Third Pole under westerly and monsoon influences. Five focused questions address: (1) challenges to green Silk Road sustainability, (2) scientific understanding and prevention of disaster risks, (3) management of human activity impacts on resources and environment, (4) climate change effects on biological and environmental co-evolution, and (5) westerly-monsoon impacts on water resources. Seven research tasks include: scientific assessment and decision support for green Silk Road construction, green development technology integration and demonstration, environmental impacts and disaster risks in key regions and projects, human activity impacts and management, climate change effects on ecosystems and biodiversity, westerly-monsoon interactions and water resource changes, and long-term resource-environment evolution. Pan-TPE aims to elucidate Pan-Third Pole environmental changes and impacts, assess resource-environment issues in key regions and major projects, and propose green development pathways for Silk Road construction.

References

1. Zheng Du, Yao Tandong. Research progress on Tibetan Plateau formation, evolution and environmental resource effects. China Basic Science, 2004, 6(2): 17-23.
2. Zhang Renhe, Zhou Shunwu. Differences in temperature trends between the Tibetan Plateau and other regions at the same latitude and possible role of ozone. Acta Meteorologica Sinica, 2008, 66(6): 916-925.
3. Chen Deliang, Xu Baiqing, Yao Tandong, et al. Scientific assessment of Tibetan Plateau environmental changes: past, present and future. Chinese Science Bulletin, 2015, 60(32): 3025-3035.
4. Yang Xue. Scientists from multiple countries discuss Pan-Third Pole environment and Belt and Road. Science and Technology Daily, 2017-07-12(3).
5. Zheng Du, Zhu Liping (eds.). Tibetan Plateau Formation, Environment and Development. Shijiazhuang: Hebei Science and Technology Press, 2003.
6. Yao T D, Thompson L, Yang W, et al. Different glacier status with atmospheric circulations in Tibetan Plateau and surroundings. Nature Climate Change, 2012, 2(9): 663-667.
7. Ye Duzheng. Seasonal variation of the Tibetan Plateau' s influence on atmospheric circulation. Acta Meteorologica Sinica, 1952, (Z1): 33-47.
8. Wu G, Liu Y, He B, et al. Thermal controls on the Asian summer monsoon. Scientific Reports, 2012, 2(5): 404.
9. Su B, Liu X, Wang Y, et al. Influence of Tibetan Plateau uplift on African and Asian primate evolution. Science, 2016, 352: 673-677.
10. Zhang Miman, MIAO DeSui. Cenozoic fish fossils from the Tibetan Plateau and their paleoenvironmental significance. Chinese Science Bulletin, 2016, 61(9): 981-995.
11. Deng Tao, Wang Xiaoming, Wang Shiqi, et al. Evolution of Neogene mammalian faunas in China and its relationship with Tibetan Plateau uplift. Advances in Earth Science, 2015, 30(4): 407-415.
12. Favre A, Päckert M, Pauls S U, et al. The role of the uplift of the Qinghai-Tibetan Plateau for the evolution of Tibetan biotas. Biological Reviews, 2015, 90(1): 236-253.
13. Zhang Peizhen, Deng Qidong, Zhang Guomin, et al. Active tectonic blocks and strong earthquake activity in mainland China. Chinese Journal of

Geophysics, 2014, 57(7): 2025-2042.
14. Cui Peng, Chen Xiaoqing, Zhu Yingyan, et al. Risk analysis of mountain hazards in Tibetan Plateau under global warming. Climate Change Research, 2014, 10(2): 103-109.
15. Hou Zengqian, Mo Xuanxue, Yang Zhiming, et al. Metallogenesis of Tibetan Plateau collisional orogenic belt: tectonic background, temporal-spatial distribution and main types. Geology in China, 2006, 33(2): 340-351.
16. Dai Junsheng, Ye Xingshu, Tang Liangjie, et al. Tectonic division and petroleum prospects of Qaidam Basin. Chinese Journal of Geology, 2003, 38(3): 291-296.
17. Wang Ting. Bibliometric analysis of international Tibetan Plateau research literature from 2009-2015 based on SCIE and ESI data. Progress in Geography, 2017, 36(4): 500-512.
18. Wang Jia. Tibetan Plateau research: a review of recent researches on effects on the Tibetan Plateau' s earth system. National Science Review, 2015, 2: 468-488.
19. Zheng Du. Tibetan Plateau research in natural science history. Studies in the History of Natural Sciences, 2003, (S1): 70-80.
20. Wang Jia. TPE international program: an international program addressing major environmental and ecological challenges in the Third Pole region. Progress in Geography, 2014, 33(7): 884-892.
21. Xinhua News Agency. Xi Jinping's speech at the Sixth Central Tibet Work Conference. [2015-09-05]. http://news.xinhuanet.com/politics/2015/09/05/c_{1116464913}.htm.
22. Xinhua News Agency. Xi Jinping' s congratulatory letter on the launch of the second Tibetan Plateau comprehensive scientific expedition. People' s Daily, 2017-08-20(1).
23. National Development and Reform Commission, Ministry of Foreign Affairs, Ministry of Commerce. Vision and actions on jointly building Silk Road Economic Belt and 21st-Century Maritime Silk Road. [2015-03-28]. http://news.xinhuanet.com/finance/2015/03/28/c_{1114793986}.htm.
24. Xinhua News Agency. Xi Jinping's important speech at the Belt and Road construction symposium. [2016-08-17]. http://www.gov.cn/xinwen/2016/08/17/content_{5100177}.htm
25. Ministry of Foreign Affairs. Belt and Road Forum Roundtable Summit Joint Communiqué. [2017-05-15]. http://www.gov.cn/xinwen/2017/05/15/content_{5194232}.htm.
26. National Research Council. Himalayan Glaciers: Climate Change, Water Resources, and Water Security. Washington, DC: The National Academies Press, 2012.
27. Liu Yuzhen, Alimujiang Kasimu. Remote sensing monitoring of desertification dynamics in typical areas along the Silk Road Economic Belt. Science of Soil and Water Conservation, 2017, 15(2): 1-8.
28. NASA. New map offers a global view of health-sapping air pollution. [2009-10-22]. https://www.nasa.gov/topics/earth/features/health-sapping.html.
29. Yao Tandong, Thompson L, Yang Wei, et al. Third Pole Environment (TPE). Environmental Development, 2013, 6: 52-64.

Yao Tandong is an academician of the Chinese Academy of Sciences, director and professor of the Institute of Tibetan Plateau Research, CAS. He has long been engaged in Third Pole glacier and environmental research, initiated and advanced the "Third Pole Environment (TPE)" international program, and pioneered Chinese mountain ice core and Tibetan Plateau Earth System science. Using precipitation stable isotopes on the Tibetan Plateau, he revealed three modes of westerly-Indian monsoon interaction that directly affect current glacier and lake changes on the plateau. These results have been published in top international journals with high impact, achieving 0.01% most-cited paper status. The research team led by Yao Tandong ranks among the top groups in the ten frontier fields of geosciences identified by Thomson Reuters (now Clarivate Analytics) in 2015 and 2016. He has received the Ho Leung Ho Lee Award and multiple National Natural Science Awards. In 2017, he was awarded the Vega Medal by the Swedish Society for Anthropology and Geography for his contributions to Tibetan Plateau glacier and environmental research. E-mail: tdyao@itpcas.ac.cn

Figures

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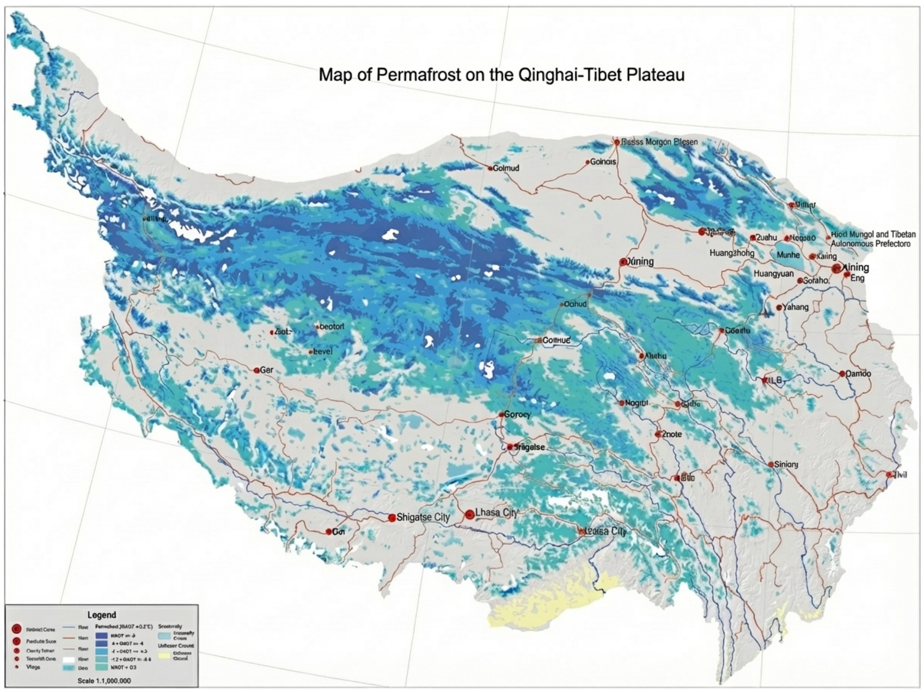

Figure 1: Figure 4

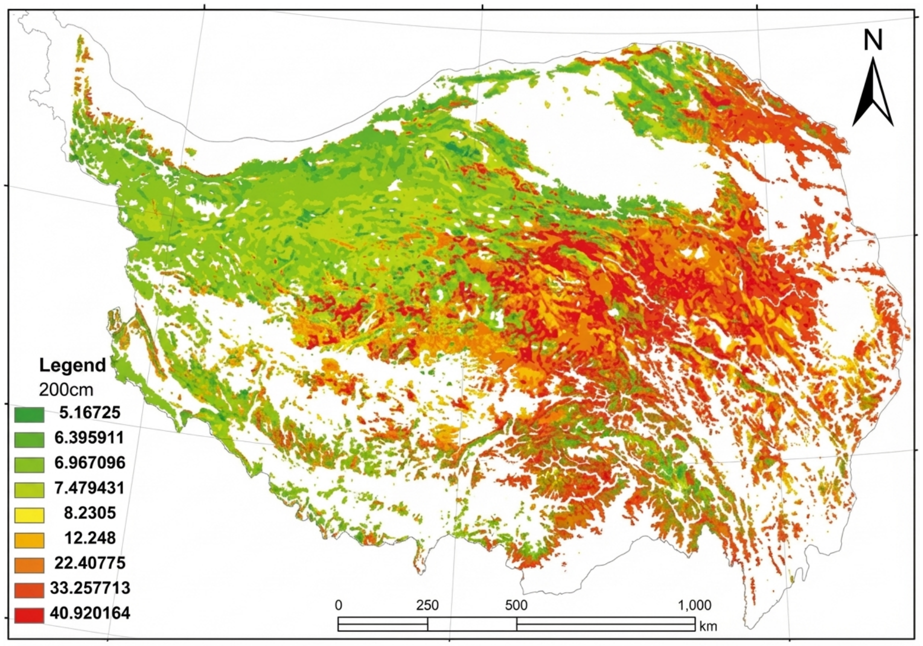

Figure 2: Figure 5