

Research on the Problems and Countermeasures of Forestry Carbon Sink Development in Northwest China: A Case Study of Gansu Province

Fuwei Qiao^{1,a}, Guanwen Ouyang^{1,b,*}, Lulu Zhao^{1,c}

¹*School of Economics, Northwest Normal University, Lanzhou, China*

^a*qfw279@nwnu.edu.cn*, ^b*oyczgw@163.com*, ^c*13389331971@163.com*

^{*}*Corresponding author*

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Abstract: Forestry carbon sinks are a critical lever for China to achieve its “dual-carbon” goals and advance ecological civilization. Situated in an arid, desertification-prone region, Gansu Province serves as a vital ecological barrier in western China; its forestry carbon sinks could transform ecological assets into green growth, yet progress remains slow. Through policy analysis and field research, this study identifies four key bottlenecks: scarce forest resources dominated by young stands; weak measurement, reporting, and verification systems; severe regional imbalances; and a critical shortage of interdisciplinary professionals. Accordingly, we propose four countermeasures: precision silviculture to improve stand quality; construction of a unified, high-resolution provincial monitoring network; establishment of regional synergy mechanisms between pioneer areas and resource-rich but lagging regions; and creation of a localized talent pipeline integrating university-industry partnerships, targeted training, and incentive policies. The paper offers a replicable model for carbon-sink development in ecologically fragile and economically disadvantaged regions.

1. Introduction

Forestry carbon sinks are among the most representative and practically viable forms of carbon sequestration, playing a pivotal role in combating climate change and advancing ecological civilization. Chinese leaders have observed that forests serve as reservoirs, treasuries, and granaries and should now be recognized as “carbon vaults” as well. This insight broadens society’s appreciation of forest value and provides fundamental guidance and an action plan for promoting forestry carbon sinks and accelerating the construction of an ecological civilization. As of 15 June 2025, among the 88 projects that have completed public notice on China’s Greenhouse Gas Voluntary Emission Reduction Registry and Information Platform, 37 are forestry or other carbon-sink types, accounting for more than 40 percent of the total. This underscores both the dynamism and the potential of carbon-sink initiatives within China’s green, low-carbon development landscape. As a crucial ecological security barrier for the country, western China must accelerate carbon-sink capacity building and expand pathways for realizing the value of ecological

products; doing so has become the key to resolving the long-standing dilemma between development and conservation in ecologically oriented western regions[1]. Gansu Province—plagued by large, widely distributed, and highly damaging desertification—faces formidable ecological-restoration tasks. Forestry carbon sinks are therefore vital to Gansu’s efforts to build a strong ecological security shield and transition toward green development. Consequently, examining the current state of forestry carbon sinks in Gansu and identifying optimal policy pathways is not only an integral part of implementing China’s dual-carbon strategy but also an essential route for converting Gansu’s ecological advantages into economic ones and for advancing the construction of a Beautiful Gansu.

2. Problems Facing the Development of Forestry Carbon Sinks in Gansu Province

2.1 Scarce total forest resources and a weak foundation for forestry carbon-sink development

Gansu’s forest resources are neither abundant in extent nor rich in volume. According to the National Land Survey Results Sharing and Application Service Platform, the province’s total forest land area in 2023 was 123.28 million mu (≈ 8.22 million ha), ranking 17th nationwide—well below the national median. Its forest-cover rate is less than 12 %, far behind the national average of over 24%. Moreover, pure stands and young or middle-aged plantations dominate the forest estate, resulting in an ecosystem structure that is fragile and highly sensitive to environmental change[2].

By the end of 2024, Gansu’s standing timber volume was below 280 million m^3 , only about 1.4% of the national total of 20 billion m^3 . Consequently, the province’s forest-carbon stock remains low, and its forest land provides only limited carbon-sink services. Meanwhile, the contiguous parcels suitable for afforestation or grassland restoration in peri-urban areas have already been largely greened. Future afforestation will have to move to remote barren hills with poor site conditions, high establishment costs and low survival rates. The financial and technical pressures associated with both planting and long-term management are therefore intensifying rapidly. The marginal cost of land greening is rising sharply: every additional percentage point of forest cover will require exponentially greater investment, making the task of further greening increasingly formidable.

2.2 Measurement and monitoring technologies still need improvement, and the carbon-sink baseline remains unclear

Gansu has registered step-wise progress in carbon-sink measurement and monitoring in recent years. In 2024, Zhangye City established the Forest and Grassland Carbon Sink Measurement and Monitoring Center and has already laid out more than 2,900 survey plots, building a preliminary background database for the city’s forest- and grassland-carbon resources. Lanzhou Municipality, in collaboration with Lanzhou University, has estimated that the combined carbon sequestration of its forests, grasslands, and wetlands totals roughly 8.08 million t $\text{CO}_2\text{-eq}$, valued at 727 million RMB.

Yet, viewed at the provincial scale, Gansu still lacks a unified carbon-sink monitoring network and a consolidated database. Monitoring capacities vary widely across the province and are not underpinned by high-precision tools. While Lanzhou New Area has piloted satellite-remote-sensing-based technologies, these have not been rolled out province-wide. Real-time and continuous data streams remain inadequate, leaving the province without a clear carbon-sink baseline. The spatial distribution, stock potential, and dynamic changes of forestry carbon sinks have not yet been comprehensively mapped, and high-frequency, high-precision dynamic monitoring is still absent. These shortcomings constrain the scientific management and commercial development of forestry carbon sinks in Gansu.

2.3 Regional disparities leave carbon-sink projects advancing at a crawl

Zhangye and Qingyang—pioneer zones for monetizing forestry carbon sinks—have already scored breakthroughs. Zhangye has transacted carbon reductions from 4 million mu of grassland, netting more than RMB 70 million; in December 2024 it pre-sold the first batch of CCER credits from afforestation projects for RMB 2 million. Qingyang has opened an account on the national voluntary-emissions trading system; its “Ziwuling Afforestation Carbon-Sink Project” is projected to generate roughly 490 million yuan in total revenue (at 70 yuan per tonne). By contrast, resource-rich prefectures such as Longnan and Pingliang are advancing sluggishly. Longnan leads the province in forest cover and commands 10.49 million mu of forest land; its 2024 non-timber forest-based economy already yields RMB 2.85 billion, yet carbon-sink trading remains fragmented. The “non-timber forest-based economy + carbon sink” model has not been effectively piloted or scaled, leaving resources idle and preventing them from capturing their full market value—an evident mismatch between assets and returns. Pingliang’s combined forest and grassland coverage reaches 44.3 %, but it has yet to integrate resources or highlight its National Forest City credentials in carbon-sink projects, slowing value realization. Similar under-exploitation of abundant forest and grassland resources is evident in Linxia, Gannan and several other prefectures[3].

2.4 A shortage of specialized talent is stalling carbon-sink project development

Forestry-carbon projects demand cross-disciplinary collaboration among forestry, environmental protection, finance, and market actors, yet China as a whole faces a chronic shortage of professionals who truly master carbon-sink methodologies and project consulting. According to the China Petroleum and Chemical Industry Federation, the country will need 550,000–1,000,000 “dual-carbon” specialists during the 14th Five-Year Plan period, whereas the current workforce is only about 100,000[4].

Located in the country’s west, Gansu lags well behind coastal provinces such as Fujian and Zhejiang in economic dynamism and industrial appeal, and its overall talent pool for carbon-sink development is markedly smaller. The shortfall is even starker when compared with more developed regions: most of Gansu’s existing forestry-carbon staff come from traditional silviculture backgrounds and lack expertise in ecological accounting, financial trading, and market operations, severely constraining the high-quality development and management of projects. Qingyang Municipality has explicitly stated that “local carbon-sink talent is urgently needed and external experts must be brought in”.

Meanwhile, developed provinces like Jiangsu, Guangdong, and Shandong have already explored new pathways—university-enterprise partnerships and targeted training programs—to cultivate talent. By contrast, Gansu’s weaker economy has prevented it from building a training system aligned with local industry demand or from attracting high-caliber external educational resources. The result is a slow replenishment of new professionals, a lagging talent pipeline, and a widening gap with other provinces[5].

3. Policy recommendations for advancing forestry carbon-sink development in Gansu Province

3.1 Precisely upgrading forest quality to expand carbon-storage capacity

First, the Gansu provincial government should implement region-specific carbon-enhancement and quality-improvement projects to raise forest quality and carbon-storage capacity. Priority should be given to ecologically critical zones such as Zhangye, Longnan and Gannan, where

low-function forests will be systematically upgraded, degraded stands restored and natural forests tended to improve stand quality and per-unit-area carbon fixation. The province should also expand mixed-species, multi-layered plantations dominated by native, site-adapted tree species to create structurally stable, multifunctional forest ecosystems that enhance ecological resilience and long-term carbon-sink potential.

Second, the Gansu provincial government should promote targeted green expansion in suitable areas and optimize the layout of “carbon-storage-oriented” forest types. Relying on the provincial “14th Five-Year Plan” for afforestation and green space planning, priority should be given to developing carbon-storage-oriented economic forests and shelterbelt forests in key areas such as water source conservation zones, sandstorm source control areas, and the southern mountainous regions. The promotion of native tree species with strong carbon storage capacity and wide adaptability—such as spruce, larch, and Chinese pine—should be encouraged, so as to enhance carbon storage while also taking into account both ecological and economic benefits.

Third, the Gansu provincial government should actively petition the central government to launch a “Special Initiative for Improving Quality and Efficiency of Forestry Carbon Sequestration in Western China”, so as to break the deadlock of rising marginal afforestation costs. It should also urge the central finance ministry to set up a dedicated fund for enhancing carbon-sink capacity in the western regions, channeling support toward tree-planting projects on barren mountains with poor site conditions and high costs. Green-financial instruments such as carbon bills, carbon bonds and carbon insurance should be introduced to ease local fiscal pressure and raise the returns on greening investments.

3.2 Strengthening the Monitoring Foundation: Building an Efficient Forestry Carbon-Sink Accounting System

First, the Gansu provincial government should accelerate the construction of a province-wide unified forestry-carbon-sink measurement and monitoring network and data platform. Building on the Zhangye Forestry and Grassland Carbon-Sink Monitoring Center and the forest-resource accounting results of Lanzhou, and benchmarking against national data standards and monitoring parameters, a multi-departmental, tiered-administration carbon-sink resource database should be created to form a provincial-level, nationally aligned data management and application system.

Second, the Gansu provincial government should strengthen the development of locally adapted carbon-sink monitoring methodologies and technical standards. Leveraging research strengths from Lanzhou University, the Northwest Institute of Eco-Environment and Resources of the Chinese Academy of Sciences, Northwest Normal University, and Gansu Agricultural University, expedite the formulation of accounting methods suited to local conditions while fully incorporating the costs of developing and protecting Gansu’s forests, grasslands, and wetlands, and integrate these into the national carbon-trading system.

3.3 Coordinated Regional Development to Unleash the Diverse Potential of Carbon-Sink Projects

First, the Gansu Provincial Government should establish a regionally tiered advancement mechanism. Based on local endowments of forest and grassland resources, carbon-sink potential, and market maturity, it should craft differentiated development pathways. For pioneer zones such as Zhangye, Qingyang, and Lanzhou, breakthroughs should be pursued in upgrading carbon-sink project quality, expanding scale, and innovating trading mechanisms, thereby creating flagship models for Gansu’s participation in the national voluntary greenhouse-gas emission-reduction market. For resource-rich but under-developed areas like Longnan, Pingliang, Linxia, and the

Gannan Plateau, a “dual-wheel” approach that couples ecological protection with high-efficiency conversion of carbon-sink resources should be prioritized. Targeted support policies should be introduced to accelerate the transition from “areas rich in forest and grassland resources” to “recognized carbon-sink contribution zones”.

Second, governments at all levels in Gansu should encourage exploration of an integrated “under-forest economy + carbon sink” development model. In areas such as Longnan and Pingliang, where the under-forest economy is relatively well developed, efforts should be made to promote deep integration of industries such as forest-based medicine, forest poultry farming, and forest wellness with carbon sink development, in order to explore a model that achieves simultaneous enhancement of ecological value and industrial income.

Third, the Gansu Provincial Government should explore a “government guidance + market operation” investment and financing model to attract social capital, green funds, ESG investors, and other diverse actors to participate in carbon-sink project development, and promote the localized application of green financial instruments such as carbon bills, carbon bonds, and carbon insurance in Gansu Province.

Fourth, the Gansu Provincial Government should encourage resource-rich areas and pilot areas to build a “co-construction, co-sharing, strong-weak linkage” cooperation mechanism in project application, technical support, methodology sharing, monitoring and evaluation, and other aspects, fostering a virtuous interaction of “strong leading weak” and “pioneer leading latecomer”.

Fifth, the Gansu Province should use policy incentives to steer the conversion of ecological resource advantages into economic returns, strengthen the endogenous drivers of green development in Gannan Plateau region, and promote coordinated regional and province-wide improvement in Gansu’s forestry carbon-sink development.

3.4 Accelerating the development of a local talent-training system and broadening the channels for talent recruitment and cultivation

First, leveraging Lanzhou University, the Northwest Institute of Eco-Environment and Resources of the Chinese Academy of Sciences, Northwest Normal University, and other provincial universities and research institutes, develop interdisciplinary professional courses covering ecological measurement, carbon-asset management, financial trading, and market operations, implement the “Higher-Education Carbon-Neutrality Science-and-Technology Innovation Action Plan” and the “Work Plan for Strengthening the Construction of Higher-Education Talent-Cultivation Systems for Carbon-Peaking and Carbon-Neutrality,” and establish a batch of carbon-neutral “bachelor-master-doctor” disciplinary and professional training systems.

Second, in accordance with Gansu’s functional positioning as an ecological security barrier, the upper Yellow River water-conservation belt, and a national key ecological-function zone, encourage all universities to set up special carbon-sink research funds, establish carbon-sink research and talent-training practice bases in key areas such as the Qilian Mountains, Ziwuling, and Xiaolong Mountains, form interdisciplinary and cross-field research teams and scientific platforms, deepen the integration of different disciplines, establish a “production–education–research–application” cooperative education mechanism, and cultivate a localized, interdisciplinary talent pool aligned with the province’s key priorities in forest and grassland carbon sinks, desert ecological governance, degraded-forest restoration, and carbon monitoring and assessment.

Third, the Gansu Provincial Government should formulate attractive talent-introduction policies, actively attract high-level carbon-sink experts and technical backbones to start businesses and provide technical guidance in Gansu, focus support on pilot areas such as Zhangye, Qingyang, and Lanzhou, alleviate talent bottlenecks, initially form talent “growth poles,” and thereby radiate to

surrounding regions to bolster carbon-sink talent.

Fourth, drawing on the advanced experiences of developed regions such as Zhejiang and Fujian in university-enterprise cooperation, customized training, and professional certification systems, the Gansu Provincial Government should rely on Gansu's forestry carbon-sink projects such as the Ziwuling Forest Afforestation Carbon-Sink Project, join forces with carbon-sink development companies such as Western Carbon-Sink Trading Asset Management (Gansu) Co., Ltd., carbon-asset assessment institutions, and forestry and grassland departments, normalize job-capacity training and practical drills, promote the transformation and upgrading of grassroots forestry personnel into practical carbon-sink professionals, and enhance the technical literacy and market adaptability of the existing workforce.

4. Conclusion

Forestry carbon sinks constitute Gansu's strategic lever for translating ecological advantages into economic gains under the nation's dual-carbon agenda. This study reveals that insufficient forest resources coupled with skewed age structures, the absence of a measurement-reporting-verification system, pronounced regional disparities, and a dearth of interdisciplinary expertise collectively constrain the province's carbon-sink potential. Remedying these constraints demands precision silviculture to enhance stand quality, a unified high-resolution provincial monitoring network to secure robust data, a "strong-leading-weak and pioneer-supporting-latecomer" regional synergy mechanism to bridge development gaps, and a localized talent pipeline to sustain innovation. These pathways will simultaneously strengthen Gansu's ecological security barrier and inject new momentum into green growth, offering a replicable and scalable model for carbon-sink development in arid, desertified and economically disadvantaged regions.

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