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Forestry offsets under China's certificated emission reduction (CCER) for carbon neutrality: regulatory gaps and the ways forward

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Abstract

Purpose – As a typical nature-based solution to climate change, forestry carbon sinks are vital to achieving carbon neutrality in China. However, regulations in China are insufficient to promote the development of carbon offset projects in forestry. This study aims to identify the regulatory obstacles impeding the development of forestry offsets under China's certified emission reduction (CCER) and explore ways to improve the regulatory system.

Design/methodology/approach – This study conducts a qualitative analysis using a normative legal research method. This study conducted a synthetic review of national and local regulatory documents to gain insights into the regulatory landscape of forestry offsets in China. The main contents and characteristics of these documents are illustrated. Furthermore, related secondary literature was reviewed to gain further insight into forestry offset regulations and to identify significant gaps in China's CCER regulation.

Findings – Forestry offset regulations under the CCER are characterized by fragmentation and a relatively lower legally binding force. There is no systematic institutional arrangement for forestry offset development, impeding market expectations and increasing transaction costs. The main challenges in China's regulation of forestry carbon sinks include entitlement ambiguity, complicated rules for registration and verification, a lack of mechanisms for incentives, risk prevention and biodiversity protection.

Originality/value – Forestry carbon sinks' multiple environmental and social values necessitate their effective development and utilization. This study assessed forestry offset regulations in China and proposed corresponding institutional arrangements to improve forestry carbon sink regulations under the CCER.

Keywords Forestry offsets, Carbon emission trade, Certified emission reduction, Carbon sink right

Paper type Research paper

1. Introduction

Climate change is one of the most challenging issues for humanity. A range of studies have predicted temperature rises under different scenarios. For example, without timely climate

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neutrality around 2050, the IPCC Sixth Assessment Report (AR6) concluded that the temperature could rise by 1.5°C in the early 2030s in most scenarios (IPCC, 2023). IEA, 2021 predicted that the global average temperature rise would be 2°C by 2050 under prevailing policy settings (IEA, 2021). UNEP, 2021 warns against a temperature rise of 2.7°C by the end of this century (UNEP, 2021). Therefore, all the states should do more to realize the goals of the Paris Climate Agreement. As the largest country emitter of carbon, China's carbon emissions have significantly affected climate goals. To achieve carbon peaking by 2030 and carbon neutrality by 2060, China has implemented various policies and laws to reduce carbon emissions since 2015, particularly those related to the renewable transition of energy structures (Xu, 2021). However, the energy structure transition is a social-technical transition with multilevel, systematic, gradual and long-term characteristics (Geels *et al.*, 2017). China should expand related tools to achieve carbon neutrality, particularly nature-based solutions (Zhao *et al.*, 2022).

Developing carbon sinks is an inevitable and feasible choice (Bastin *et al.*, 2019). The Paris Climate Agreement explicitly calls for all countries to fully use land-based mitigation options, including forest management (Krug, 2018). Nature-based solutions, including forestry carbon sequestration, are estimated to provide 10 Gt of CO_2 reduction per year in a cost-effective scenario (Girardin *et al.*, 2021). Climate action is also helpful for sustainable development (Garg, 2020). Costs can be reduced by implementing mitigation and forest protection policies (Matsumoto *et al.*, 2019).

Forestry carbon sequestration is currently receiving increasing attention (Wade *et al.*, 2022), and related studies have addressed various aspects of reducing emissions from deforestation and forest degradation (REDD+) (Sandker *et al.*, 2010). The literature includes the implementation, impact and governance of forest sink projects, including their impact on forest transition (Culas, 2012), protected land management (Scharlemann *et al.*, 2010), community-based forest management (Robinson *et al.*, 2013), power relations that shape forest policy (Boer, 2020) and the economics of related projects (Pandit *et al.*, 2017).

A high-quality carbon offsets regulation should result in effective and long-term carbon sinks, ensuring social justice, equity and the preservation of biodiversity (Pan *et al.*, 2022). Mansourian *et al.* (2022) summarized the experiences stemming from the different phases of REDD+ in over 65 countries. They highlighted the importance of the rights of local communities, the ownership and accountability of stakeholders and adequate incentives for forestry carbon project implementation. Evans (2018) stressed the role of information, institutions and incentives in large-scale reforestation. Drever *et al.* (2021) suggested that respect for indigenous people and biodiversity safeguards are the best practices for natural climate solutions (NCS).

Furthermore, forest carbon mitigation requires a comprehensive institutional arrangement, among which transparency and accountability are key prerequisites for sustaining public support and investment in carbon-focused forest management (Guillaume *et al.*, 2018). Fleischman *et al.* (2021) suggested that more attention should be paid to the underlying political reforms regarding enforceable rights, representative and accountable institutions, clear incentives and symmetrical power relations. After exploring offsets regulation in the compliance markets of Europe, the USA and China, and the Clean Development Mechanism, Arup and Zhang (2015) emphasized a greater control of the shares, sectors, sources and standards of offsets than was initially chosen. A carbon sequestration right in the form of an easement is helpful to ensure permanence as well as enforceability and transferability of forestry offsets (Abigail, 2012). Through the case study of the Canadian province of British Columbia, St-Laurent *et al.* (2017) identified six barriers to the development of forest carbon offsetting, including deficiencies of carbon markets;

limited economic benefits; uncertain climate effectiveness; negative public opinion; limited and uncertain property rights; and governance issues.

Although forest sequestration is a relatively less costly mitigation measure that may synergize multiple targets, challenges exist in operationalizing this approach (Gren and Aklilu, 2016). To realize synergies, policymakers must fill the institutional gaps between mitigation and forest conservation regulations and enforce SDG policies (Broekhoff and Spalding-Fecher, 2021). However, regulations on forestry offsets have not been sufficiently addressed in China. Most studies on China's climate change response have focused on energy structure transition (Xu, 2021), carbon emission trading (Yan *et al.*, 2020), renewable energy quotas (Xiong *et al.*, 2014) and electricity price subsidies (Ouyang and Lin, 2014). In contrast, few studies have systemically addressed China's forestry offsets regulations (Yang *et al.*, 2021). However, institutional issues play a critical role in effective forestry offsets. Therefore, a systematic analysis of forestry offset regulation is necessary to identify regulatory gaps based on which more effective institutions can be established to achieve carbon neutrality in China. This study aims to identify the institutional obstacles and deficits impeding the large-scale development of forestry offsets in China. It explores necessary reforms to promote effective and efficient forestry offset governance.

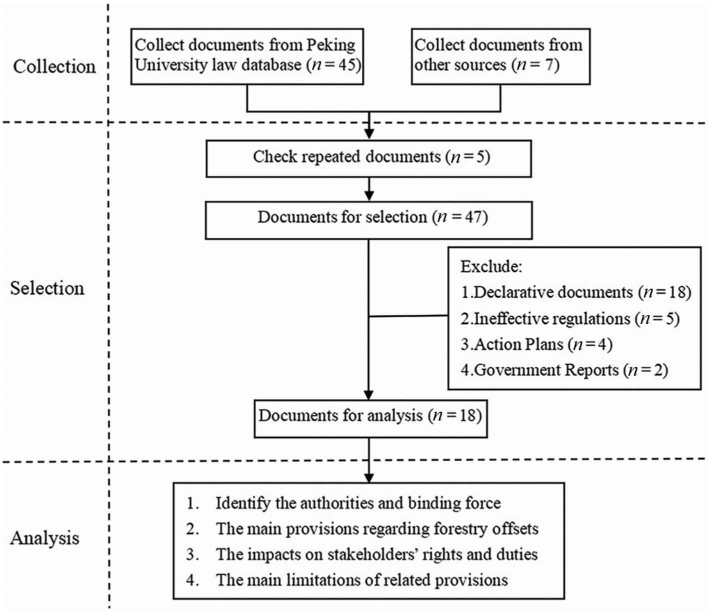
2. Methods

This study conducted a qualitative analysis using a normative legal research method based on applicable laws and regulations. This method analyzes "learning in the form of documents, using various secondary data, namely regulations in legislation, court decisions set by judges, and legal theories" (Adnan and Sunarto, 2020). Normative legal research focuses on an inventory of positive law, legal principles and doctrines, legal systematics, comparative law and legal history (Karjoko *et al.*, 2020). It examines related legislation and policies on the issues handled to describe the regulatory landscape and its main contents and characteristics (Indriati and Nugroho, 2022).

The initial step is to collect primary and secondary legal material regarding the regulations and other literature related to the issue studied. Data collection for normative legal research is conducted through library research. The primary regulatory documents reviewed in this study mainly concern CCER and carbon emissions at the national and local levels. These documents include national and local laws, regulations and policies. Figure 1 shows a flowchart of the normative legal research used in this study.

The regulatory documents were derived from the following sources: public data, mainly from the Ministry of Ecology and Environment, the National Development and Reform Commission (NDRC) and other relevant authorities; the Peking University law database. According to the document selection process in the flowchart, 18 documents were selected for analysis. Seven national regulations and policies for CCER are listed in Table 1, and three representative documents were selected at the local level, including the 2017 Pilot Scheme of Forestry Carbon Sequestration Trade in Fujian Province, the 2021 Administrative Measures on Development and Trading of Forestry Carbon Sinks in Jiangxi Province (Trial) and the 2021 Forestry Carbon Ticket Management Measures (Trial) of Sanming City.

Carbon emissions trade regulations include the 2020 Measures for the Management of Carbon Emission Trading (Trial) issued by the Ministry of Ecology and Environment and local regulations of eight pilot areas: Beijing, Tianjin, Shanghai, Chongqing, Hubei, Guangdong, Fujian and Shenzhen. The forms, contents, legal force and effects of these regulations and policies are discussed to describe the institutional supply of forestry offsets.



Source: Author's elaboration

Figure 1. Flowchart of the method

Year	Authorities	Document	Main contents
2012	NDRC	Interim Measures for the Management of Voluntary Greenhouse Gas Emission Reduction Trading	The application and approval of forestry carbon credits
2014	National Forestry Bureau	Guidance on Promoting Forestry Carbon Sink Trading	Exploring mechanisms for Integrating CCER into carbon emission trading market
2016	State Council	Opinions on the Perfection of Forestry Rights of Communities	Integrating carbon sinks into the carbon market
2018	CPC Central Committee and the State Council	Opinions on Implementing the Strategy of Rural Revitalization	Ecological restoration participating in carbon sink trade
2020	Ministry of Ecology and Environment	Measures for the Management of Carbon Emission Trading (Trial)	Establishing and improving the national carbon emission market
2021	General Offices of the CPC Central Committee and the State Council	Opinions on Deepening the Reform of the Ecological Protection Compensation System	Integrating CCER into the national carbon emission trading market
2021	The CPC Central Committee and the State Council	Opinions on Completely, Accurately and Comprehensively Implementing the New Development Concept and Achieving Carbon Peaking and Carbon Neutrality Goals	Integrating carbon sinks into the national carbon emission trading market

Source: Author's compilation based on the official websites of related authorities 2023

Table 1. Selected regulatory documents on CCER

Regulations on the carbon emissions trade were analyzed to identify limitations for the inclusion of forestry offsets.

Qualitative and descriptive analysis is used to analyze the data. This analysis is made by "conducting research by observing the natural state of the object, describing and summarizing the characteristics of the collected data relating to the problem being studied" (Adnan and Sunarto, 2020). This study uses regulatory status as the foundation for further analysis. A synthetic review of national and local regulatory documents was conducted to gain insights into how forestry offsets are regulated in China. Furthermore, journal articles, comparative legal material, institutional reports and working papers were reviewed to gain further insights into forestry offset regulations and identify significant gaps in China's CCER regulations.

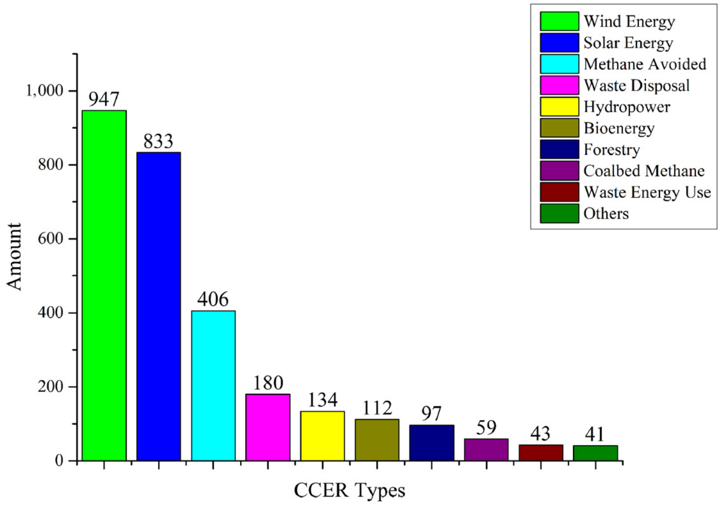
3. Development and regulation status of forestry offsets under China's certified emission reduction

3.1 Development of forestry offsets under China's certified emission reduction

A market-based approach to reducing carbon emissions is cost-effective, efficient and flexible (Swallow and Goddard, 2016). Forestry offsets can be traded through the carbon emission trading market. This may incentivize investments in forestry offsets. However, challenges exist for forestry offsets to function well in reducing carbon emissions, including negative impacts on companies' efforts to decarbonize (Boyd, 2022), improvement needs in carbon accounting methodologies (West *et al.*, 2023) and defects in pricing and incentive mechanisms (Boyd *et al.*, 2023). The development of CCER in China reflects the difficulties in CCER development and the need for a proper and sustainable CCER institution.

In June 2012, the NDRC issued the Interim Measures for the Administration of Voluntary Emission Reduction Transactions of Greenhouse Gases, stipulating procedures for the inclusion of the CCER in the carbon trading system. However, according to the China Voluntary Emissions Reduction Trading Information Platform, afforestation, reforestation and sustainable forest management projects are rare in China. Most projects are renewable and new energy projects, including wind power, photovoltaic power, methane utilization, hydropower, waste incineration, biomass power generation and other types of projects (see Figure 2). In addition, carbon sequestration through afforestation projects accounted for 84.6% of the recorded forestry projects, while forest management projects and bamboo management projects accounted for 7.7% (Chen, 2021).

The potential for forestry carbon credits is expanding in the carbon trade market with the increasing demand for the CCER. Regarding market demand, the national carbon emissions market includes more than 2,000 key emitters in the power generation industry, with carbon emissions of more than 4 Gt CO_2 (Cinda Securities, 2021). However, the cumulative trading volume of the CCER market exceeded 300 million tons, indicating that many CCERs had not been used to offset performance by key emission control enterprises. Specifically, forestry carbon credits traded were about 2 million tons, accounting for only 0.74% (Guangzhou Futures, 2021). The trading volume is relatively small, and individual projects are not sufficiently standardized. On March 14, 2017, the NDRC suspended the application for voluntary emission reduction transactions, including forest carbon sink trading. However, with the development of the carbon emission market in China, the need for CCER is becoming more urgent. On July 7, 2023, the Ministry of Ecology and Environment issued the draft of the Management Measures for Voluntary Greenhouse Gas Emission Reduction Trading (Trial), indicating the acceleration of restarting CCER trading.



Source: Author's elaboration based on the Report on China's CCER Progress data Carbon Peace (2021)

Figure 2. Quantity distribution of China's CCER projects by 2020

3.2 Regulation on forestry offsets under China's certified emission reduction

The limitation of forestry carbon sink trading reflects a shortage in the institutional supply of forestry carbon sinks. Forestry carbon sink trading is subordinate to carbon emissions trading and regulated by policies and laws. As multiple governance systems are necessary to combat climate change, legislation and governance at the local level also play vital roles in forestry carbon sink development (Peel *et al.*, 2012).

Although CCER can be traded in the carbon emissions market, it is subject to certain restrictions. National and local carbon emissions trading regulations typically set the upper rate for CCER that an enterprise can purchase. For example, according to Article 29 of the 2020 Measures for the Management of Carbon Emission Rights Trading (Trial), key emitters can use CCER to offset 5% of the yearly carbon emission quota. Before issuing relevant national regulations, local governments usually set caps on CCER and location or time restrictions (see Table 2).

4. Remaining regulatory gaps for forestry offsets under China's certified emission reduction

The forestry offsets regulation literature shows that legal rights and benefits distribution arrangements, risk prevention mechanisms, economic incentives and transaction costs and biodiversity protection issues are crucial for implementing forestry carbon sink projects and regulations. An interview with experts from five Chinese emission trade pilots highlighted the challenges of potential disputes between landowners and forest carbon project developers, the transaction costs incurred by project design and validation, carbon accounting and monitoring for the entire project (Shrestha *et al.*, 2022). Uncertainty in sequestration, additionality and permanence affects an effective policy design (Gren and Aklilu, 2016). In addition, synergizing biodiversity and carbon reduction targets are necessary considerations when designing forestry offset regulations. In fact, intensive carbon farming probably disrupts native forests (Rontard and Hernandez, 2022), whereas

Area	Rate (%)	Type	Location	Time
Beijing	5	CCER; energy conservation offsets; forestry carbon offsets	Offsets from areas outside Beijing cannot exceed 2.5%; priority for areas contracting with Beijing	Forestry carbon offsets after February 16, 2005
Tianjin	10	CCER; excluding hydropower	Priority for Beijing, Tianjin and Hebei	After January 1, 2013
Shanghai	5	CCER	None	After January 1, 2013
Chongqing	8	CCER; excluding hydropower	None	After December 31, 2012
Hubei	10	CCER; including small scale hydropower	Hubei; Provinces cooperated with Hubei (less than 50,000 tons)	None
Guangdong	10	CCER; 50% CO_2 and 50% CH_4 Excluding fossil energy utilization projects	70% from Guangdong	None
Fujian	10	CCER; excluding hydropower	Fujian	None
Shenzhen	10	CCER	None	None

Source: Author's compilation based on the documents obtained from the Peking University law database 2023

Table 2.
Local limitations on CCER offsets

carefully enforced safeguards for the conversion of natural ecosystems can improve the carbon and biodiversity outcomes (Heilmayr *et al.*, 2020). However, current regulations in China still need to sufficiently address these issues, and the deficiencies have impeded the development and trade of forestry offsets.

4.1 Undefined property of forestry carbon sink rights

Forestry carbon sink rights are closely related to forestland ownership, contract management and usage rights. However, the complexity of the power structure determines the diversity of ownership of carbon sinks. A project developer is often inconsistent with the forestland owner, contractor, or other users. In the context of China's forest rights reform, the ownership and contracted management rights of some collective forestland are separated, and how contracted operators and village collectives share the ownership and income of carbon sinks needs to be further clarified (Yang, 2021). The absence of clear rules for forestry carbon sink rights often leads to rights disputes and affects the implementation of carbon sink projects. For example, in the reforestation project in northwestern Guangxi, part of the forestland could not be afforested owing to land disputes (Chen, 2021).

4.2 Lack of risk prevention mechanisms

China's forestry carbon sink management mainly consists of application, certification and trading norms; however, detailed requirements for the management of certified projects are absent, which may lead to an actual increase in carbon sinks being less than the certified quantity because of poor forest management (Richards and Huebner, 2012). In addition, the formation and value of carbon sinks require forestland to maintain a sustainable management model for a long time and prevent carbon leakage caused by artificial or natural causes (Shuang and Dou, 2019). For example, the maintenance of carbon sink projects is affected by rights disputes; the loss of carbon sinks is caused by operations and management not meeting sustainable management requirements; or they are lost because of disasters such as floods and fires, which reduce and affect the sequestration capacity. Furthermore, correctly quantifying the uncertainty of emission reductions is essential for safeguarding the environmental integrity of these projects (Yanai *et al.*, 2020).

These risks highlight the importance of proper performance guarantees, risk prevention and legal relief (Zhang and Deng, 2016). To prevent the risk of carbon sink loss, some places have stipulated that forest lands and trees planned to be cut during the monitoring period are not qualified for forestry carbon stamps, but this restriction does not limit cultivation and cutting for forest management purposes. However, this regulation considers logging without considering other risks, and its failure to clearly define forest conservation and planned logging will also lead to new controversies.

4.3 Insufficient incentive mechanisms

The cost of carbon sink development consists mainly of abatement and transaction costs (Sohngen, 2009). The former is defined as the opportunity cost of changing the original operation and utilization mode to a new one, emphasizing the maintenance or increase in the carbon sequestration function of the forest (Lipper *et al.*, 2010). The abatement cost is more of a technological and economically determined issue, whereas the transaction cost is more affected by institutional design (Cacho *et al.*, 2005). Transaction costs include arranging a contract to exchange property rights ex ante and monitoring and enforcing the contract ex post (Matthews, 1986). Transaction costs are divided into those related to search, negotiation, approval, administration, monitoring, enforcement and insurance (Cacho *et al.*, 2013). The optimal scale of a carbon sequestration forest is negatively correlated with the abatement cost and transaction cost and positively correlated with the regulatory intensity of the carbon emission quota and the price of carbon sequestration per unit (Gren and Aklilu, 2016).

The scarcity of forestry CCER projects and transactions in China indicates that more economic benefits are needed to motivate the relevant rights holders. Forest operators would change their management practices when the benefits surpass opportunity costs (Ndjondo *et al.*, 2014). On the one hand, related regulations provide overly complicated regulations on forestry carbon sinks' verification and trading processes. A high technical threshold increases the transaction cost of forestry offset projects, which disproportionately disadvantages smaller forest operators (Wise *et al.*, 2019). Furthermore, forestry carbon sinks and emission quotas were calculated in a 1:1 ratio when participating in carbon emissions trading. However, China's overall carbon price is relatively low; therefore, forestry carbon sinks often require a considerable scale to maintain economic efficiency. The estimated cost of forestry offsets is approximately 200 yuan/ton, while the price for carbon reduction in the market is approximately 40 yuan/ton (Long *et al.*, 2020).

4.4 Omissions on biodiversity protection

Increasing forestry carbon sinks to cope with climate change requires expanding forest scale and enhancing forestry CO_2 absorption capacity. Although providing a resource base for biodiversity conservation is generally beneficial, it may also adversely affect biodiversity because of unreasonable human intervention. For example, the large-scale planting of genetically modified fast-growing tree species and the excessive use of pesticides and fertilizers can adversely affect biodiversity (Lin, 2018). As ecosystems are characterized by the interplay between their various components, such as water, forests and agricultural land, an integrated approach combining climate mitigation and biodiversity protection is required (Muthee *et al.*, 2017). The Cancun "safeguards" on REDD+ explicitly state that REDD+ activities should focus on enhancing forest ecosystem services and not transforming natural forests (Gardner *et al.*, 2012).

Although relevant projects in China's forestry carbon sink management should protect biodiversity, there is a lack of specific institutional arrangements. The environmental impact assessment system has been established in China, but it does not apply to forestry carbon projects. Furthermore, no unified biodiversity evaluation methods or index systems are available. The environmental impact assessment of biodiversity in forestry carbon sink projects is often a qualitative description that lacks forecasting analysis and cannot secure biodiversity conservation (Wang and Fan, 2013).

5. Suggestions for improving regulation on forestry offsets under China's certified emission reduction

Deficits in regulations impede the development of carbon sink projects required for carbon neutrality. Practices in various jurisdictions provide valuable insights for China to improve its carbon sink regulations. The following measures are urgently required to promote the development of China's forestry carbon sinks.

5.1 Clarifying forestry carbon sink rights and trading rules

The particularity of carbon emission reduction is different from the general real right object, which makes the forestry carbon sink right have the property of the quasi-real right (Lin, 2013). In some jurisdictions, carbon sink rights are explicitly defined as profits à prendre based on the carbon dioxide storage capacity.

To promote the forestry carbon sink trade, legislation may clarify the legal nature of forestry carbon sink rights. China's constitution stipulates that the state or the community owns forests, but other entities can obtain their management rights. A collective forestland contract includes the transfer of forest resources, and forest carbon sink rights are attached to the ownership of trees and other carbon sink resources. Therefore, forest management rights holders have a corresponding carbon sink without a special agreement. However, suppose forest management rights are separated from carbon sink rights and traded separately. In that case, it will put a new burden on its forestry operations to ensure that the forest carbon sink rights can meet the needs of the buyer, namely, the new forest carbon sink right owner, as agreed. Therefore, forestry carbon sink rights usually require the agreement of the owners of land, trees and management rights.

In addition, the main risks of forestry CCER projects are market and policy risks (Jin *et al.*, 2018). The initial investment and forestry CCER project development cycle are significant, and there is still considerable uncertainty in the development process. Government departments must formulate trading rules for forestry offset projects as soon as possible to reduce the policy risks of project development.

5.2 Risk prevention mechanism

As for preventing forestry offset risk, practices provide abundant references. Carbon sink systems, such as the Verified Carbon Standard, the Gold Standard, the Clean Development Mechanism, the Climate Action Reserve and the American Carbon Registry, include criteria for managing the risk of reversals through discounts and buffers (Streck, 2021). The typical approaches are as follows:

- Discount: In calculating the value of the forestry carbon sink, the possible loss of carbon sink is considered, and the discount is adopted. The possible loss of carbon sink is deducted through a discount in advance (Radke *et al.*, 2020).
- Reserved forests: Under this form of insurance, the project owner divides the forest into two unequal areas. A more significant portion is the actual sequestration project, while a smaller portion is the reserved forest. Reserved forests are also managed to store carbon to reduce and offset emissions if sequestration projects are damaged. Under the Chicago Climate Exchange, for example, a reserved forest is equal to 20% of the forest. If it does not have a targeted sink project that meets the reduction requirements, its emissions are counted toward the project to offset the difference (Abigail, 2012).
- Buffer pool offset: In California, the Forest Accord requires project owners to contribute a portion of their offsets to the buffer pools. If carbon sequestration or storage is inevitably reversed, the reserve pool deducts an equivalent amount of the carbon sink credit (Lee *et al.*, 2013). The Forest Accord risk assessment provides an example. If an offsetting project receives ten credits and the project's risk rating is 10%, the project owner's account will receive nine units of carbon sink, with the remaining 1 unit credited to the reserve pool. The project's risk was assessed once a year. If the risk is reduced during the entire life cycle of the project, the carbon sink quota will be transferred from the reserve pool to the personal account; otherwise, if the risk increases, the reserve pool quota will be increased, and the personal account quota will be reduced (Abigail, 2012).
- Carbon sink insurance: Carbon sink insurance covers two types of risks in the operation process of forestry carbon sink projects: traditional project risks, including immature technology, natural disasters, engineering accidents and management errors; and policy risks in carbon sink certification. For example, in New Zealand, forest farm operators can introduce carbon sink insurance to ensure the implementation of carbon sink projects to address natural disasters, such as floods, droughts, fires, volcanic eruptions, wind disasters and illegal logging (Zhang, 2015).

5.3 Incentive mechanism

The incentive mechanism for forestry carbon sink trading may focus on reducing transaction costs, promoting economies of scale and simplifying carbon sink certification procedures:

- Bundle scattering projects: Under the forest rights reform, scattered forestry contractors face significant investment pressure, natural risks and operational risks. A common property, rather than an individual property, is more feasible for operationalizing forestry carbon development, and this arrangement incurs lower total transaction costs than an individual property (Ostrom, 1990). Furthermore, this arrangement can reduce monitoring and enforcement costs as social interaction in a group brings autonomous governance (Sandbrook *et al.*, 2010). In addition, the creation of institutions and financial intermediaries to bundle projects into a portfolio can reduce transaction costs.
- Simplify application procedures: forestry offsets provide a nexus in which various institutions involved in climate change, biodiversity, forestry and development come together, collaborate or compete. This complexity may disadvantage, in

particular, stakeholders with less-developed organizational or financial capacities because they are ill-equipped to keep track of, participate in, or benefit from a plurality of institutions and discussions (Zelli *et al.*, 2019). The application procedure could be simplified, and forest carbon sink assessment may be provided to the community as a public good to reduce application and certification burdens. Government departments may also take the initiative to organize relevant rights holders to register forestry offsets and provide corresponding support.

- Prioritize forestry credits: As the forestry carbon sink enters the carbon market, considering its diversified ecological and environmental functions and social benefits in increasing the income of low-income groups, the priority of purchasing forestry carbon sinks may be guaranteed under appropriate circumstances according to the actual supply and demand situation. In addition, the cap on the CCER offset rate for emitters could be increased to provide more incentives for the forest sector and make full use of the forest sink (Krug, 2018). This will help scale up forestry carbon sink projects and increase profitability. Furthermore, local governments may reform and improve the regulatory system related to forestry carbon sink trading to reduce the local protectionist tendency toward carbon sink emission reduction. Local government regulatory departments may improve the information disclosure system for forestry offset trading to protect the interests of farmers and ensure the quality of forestry offset projects.
- Providing more financial support: Carbon-sequestered forests are conducive to poverty alleviation and ecological protection. In addition to ecological compensation provided by the government, forestry carbon offset trading can provide more income sources for poor areas (Cao *et al.*, 2023). The key to generating sustainable poverty reduction may be related to selling the emission reductions generated by projects. For example, the Hubei provincial government disclosed that agricultural and forestry CCERs had brought more than 7m RMB (US$1.038m or AU$1.47m) to poor areas during 2014–2017 (Zhang *et al.*, 2023). However, early investment and risk are also significant. Government investment guidance and market financing are crucial. Although financial poverty alleviation funds can attract social capital to rural areas, they cannot meet the development needs of forestry offsets. Banks could also provide forestry carbon sink projects with more green financing products (Tang, 2020).

To expand the scale of forestry offset transactions and allow more farmers to participate, regulatory authorities may establish a support and incentive mechanism for the main body of forestry offset transactions. Specifically, regulatory authorities may provide preferential and financial support to entities participating in forestry offset trading, including tax credits, financial subsidies and loan interest discounts.

5.4 Biodiversity protection mechanisms

Inherent trade-offs among ecosystems in emission reduction potential, the opportunity cost of foregone development and biodiversity values require a regulatory framework to balance emission reduction interventions with biodiversity co-benefit targets (Paoli *et al.*, 2010). An ideal forest carbon sequestration project could increase carbon sinks, maximize adaptation functions and coordinate ecological, economic and social targets. The biodiversity benefits of REDD+ can be doubled while incurring only a 4% to 8% reduction in carbon benefits, depending on the amount of REDD+ funds expended (Venter *et al.*, 2009). Currently, the measures or mechanisms for maintaining biodiversity in forestry offset activities and practices mainly include the following:

- Use floating weights based on the biodiversity level. This approach applies a discount or multiplier to the value of forest carbon sequestration projects based on biodiversity benefits. The benefits of REDD+ activities with high biodiversity benefits can be increased, whereas the value of carbon sinks with insignificant or adverse biodiversity benefits can be reduced. This option provides market incentives for investing in activities with greater biodiversity benefits. To ensure that the number of approved carbon sinks is the same as the actual number, projects that damage biodiversity are reduced in proportion.
- Set standards for protecting biodiversity. According to the biodiversity protection standard, obtaining certification as a forest carbon sink depends on meeting the minimum standards for biodiversity conservation. For example, projects that use invasive alien species or genetically modified trees are not eligible because they pose risks to biodiversity. In this regard, it is necessary not to destroy the original biodiversity or cause new resources and environmental problems, such as the excessive consumption of water resources and simplification of species, owing to the pursuit of increasing carbon sinks.
- Implementing environmental impact assessments for carbon offset projects: The 1992 Convention on Biological Diversity requires parties to adopt appropriate procedures to assess the environmental impact of proposed projects to avoid or reduce significant adverse impacts on biodiversity. Therefore, the impact of forest carbon sequestration projects on biodiversity must be included in environmental impact assessments (Arendt *et al.*, 2021). This measure will be beneficial for evaluating the influences of these projects on the ecosystem and biodiversity and putting forward scientific and feasible ecological construction plans to effectively prevent the forestry offsets project from destroying the environment to realize sustainable development of the economic community and biodiversity conservation.

6. Conclusion

With the carbon peak and neutrality targets, both source control and sink increase measures are necessary for China. Measures to increase carbon sinks, represented by forestry carbon sinks, may positively affect the climate, ecology, society and economy, which are indispensable for achieving sustainable development. China has proposed to restart the CCER market, but the CCER institutions are still in their infancy. A sustainable and effective CCER market requires proper institutions and good governance. The systemic review of the policy supply for forestry offsets in China reveals four regulatory gaps, including uncertainty about the legal nature of carbon sink rights and defects in incentive, risk prevention and biodiversity protection mechanisms. As to these aspects, China could learn from best practices in other carbon offset markets. For example, integrated institutions are needed to mitigate transaction costs and increase profits from forestry-offset development through enlarged market needs, simplified procedures, risk prevention and economic incentives. Forestry offsets may have priority in carbon markets, and the percentage or regional limits may be gradually loosened according to carbon market development and climate mitigation needs. In addition, considering the co-benefits of forestry carbon sink projects, more compensation mechanisms for biodiversity protection or poverty reduction can be used in addition to carbon trade. The benefits of local communities should be secured, and their participation in the development of forestry carbon sink projects is key to the sustainability of these projects. Furthermore, targets for forestry carbon sink development may go beyond emission reduction. The coordinated realization of various targets could be sought, and multiple values of forestry carbon sink development may be explored using practical and effective institutional designs.

This study addresses general institutional considerations and challenges related to forestry offsets. It contributes to the literature on forestry offsets regulation in two aspects. First, a more systemic analysis of China's CCER regulation is provided, expanding the jurisdictional scope of the forestry offsets regulation. Second, this study summarizes the best practices of forestry offset mechanisms, which can also be a reference for designing and evaluating related mechanisms in other jurisdictions. However, the economic and environmental contexts are diverse. Consequently, more complicated institutional designs are required to satisfy various social needs. In addition, as a typical payment for ecological services, forestry offsets will bring systemic changes to economic circulation, which will require more attention in future studies.

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