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Forest carbon market-based mechanisms in India: Learnings from global design principles and domestic barriers to implementation

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ABSTRACT

Forest carbon markets (FCMs) have emerged as a significant means to direct resources toward urgent climate action that can mobilize a large set of actors and catalyze funding toward reducing deforestation and promoting sustainable forest management. Here, we conduct a critical qualitative review of global academic and investigative literature to identify ten major sets of design principles that provide a platform for the functioning of carbon markets worldwide. From these, we pinpoint four design principles which may be relevant to future market-based mechanisms in India We propose that clarity over market-quality standards, comprehensive regulatory framework, minimization of transaction costs and upfront financing options, and flexibility in time-bound and spatial commitments would be fundamental to ensure that market-based mechanisms in India accrue sustainable and long-term benefits to climate action and human well-being. A successful market-based mechanism in India's forestry sector would have to overcome challenges around land property rights, local implementation capacities and knowledge gaps, and incentive structures to ensure that it likely caters to the needs of all stakeholders while delivering socio-ecological benefits.

1. Introduction

Forest carbon markets (hereafter, FCMs) have emerged as an alternative source of mobilizing resources for mitigating climate change. Typical FCMs function based on the idea of forests as sites for carbon removals (Nunes et al., 2020), where credits may be generated through avoided deforestation or afforestation, improved forest management practices, and reforestation drives. Consequently, transactions are measured through the carbon dioxide equivalents (CO_2eq) generated or averted. Registered projects, either led by individual entities or organizations, need to meet a certain set of standards for the sequestered carbon to be registered as credits (Chizmar & Parajuli, 2021). These registered projects are evaluated and verified for the removal of additional atmospheric carbon, in addition to ensuring its permanence and leakage prevention outside project boundaries. In this way, FCMs render carbon as a commodity to be traded in a market (Myers, 2021).

Countries in the Global South are home to some of the most carbon-dense forests in the world (Santoro et al., 2020). Consequently, a majority of active forest carbon projects are concentrated in tropical forests in Central and South America, Western Africa, and Southeast Asia (O'Kelly, 2023a). However, there is mixed evidence on whether these projects are investible in the long run given land use constraints (Koh et al., 2021, Zeng et al., 2020). Meanwhile, the impacts of these projects on local community well-being remain ambiguous and under considerable scrutiny (Aggarwal & Brockington, 2020).

India is the tenth largest forested country in the world (Food and Agriculture Organization, 2020). It has ambitious national and international climate action commitments and is dedicated to a net-zero carbon pledge by 2070 (Press Information Bureau, 2022). India's Nationally Determined Contribution (NDC) as part of the Paris Agreement aims to create an additional carbon sink of 2.5 to 3 billion tonnes of CO2eq through additional forest and tree cover by 2030 (Singh et al., 2021). Moreover, India is a signatory to the Bonn Challenge, promising to restore 21 Mha of degraded and deforested land by 2030 (Press Information Bureau, 2019). The Indian Government also seeks to accelerate existing afforestation targets like the National Mission for a Green India (GIM) (merged with the National Afforestation Program (NAP)) and as such, significant financial resources are being channeled towards these flagship programs (Roy, 2020; Press Information Bureau, 2022).

Recently, the Indian Parliament passed the Energy Conservation

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(Amendment) Bill which empowers the central government to implement a domestic carbon credit trading scheme (Press Information Bureau, 2023). In the recent Union Budget (2023–24), the Green Credits scheme was introduced as a further complement to reward positive environmental actions (Sirur, 2023). India's forestry sector may eventually come under the purview of such policies as a source of generating green/carbon credits. Consequently, exploring the role and realization of a market-based mechanism is crucial both to drive effective climate action as well as to revitalize India's forestry sector.

Considerable opportunities and challenges exist as a forest-centric market-based mechanism is developed in India. According to the latest India State of Forest Report 2021 (Forest Survey of India, 2021), the total forest and tree cover in India is 80.9 Mha, encompassing 24.62 % of the total land area; and directly serves the livelihood needs of about 300 million people (Roy, 2020). Gopalakrishna et al. (2022) estimated a total of 39.9 Mha of state-wise agroforestry potential areas in India considering the bioclimatic factors and existing land-use practices (like shifting cultivation).

However, translating these commitments into on-the-ground action effectively and equitably remains a substantial challenge: evidence suggests that previous reforms in the forestry sector have failed to provide adequate safeguards for local forest-dependent communities (Runacres, 2020; Rana et al., 2022). In that line, Choksi et al. (2023) stressed that forest restoration programmes can only be successful if socio-ecological requirements and outcomes are treated at par with biophysical restoration potentials.

In this paper, our central question is: 'What kind of design principles would likely make a market-based mechanism in the forestry sector successful in India?' To answer this question, we first conduct a critical literature review to identify scholarly literature which discusses carbon market design principles across geographies and circumstances. Using an inductive approach, we then identify four principles most relevant to the Indian context, discuss their on-the-ground challenges, and suggest likely solutions to address them. The set of high-integrity design principles that we identify speak to existing global narratives and the socio-ecological pillars of sustainability while being deeply rooted in the Indian scenario. However, designing a successful market-based mechanism for the forestry sector in India would not be straightforward. In the last section, we discuss three fundamental challenges based on previous evidence from reforms in the Indian forestry sector that may inhibit the functioning of a future market-based mechanism and how the proposed design principles likely offer possibilities to remediate those challenges.

2. Methodology

Our methodology consists of two parts. First, we conducted a critical review of academic and policy literature to identify prominent design principles discussed in carbon markets (both forest and non-forest) in other regional and global contexts (Wright & Michailova, 2023). This was followed by classifying these principles into broader sets. Second, we shortlisted these sets of principles based on relevance and frequency of their occurrence in the reviewed literature.

2.1. Critical literature review

We used peer-reviewed and investigative sources for the critical literature review. We searched the following databases to identify sources: Academia, CAB Abstracts, Directory of Open Access Journals (DOAJ), Google Scholar, ISI Web of Science, JSTOR, PubMed, and Semantic Scholars. We systematically searched the Google search engine up to 10 pages for investigatory articles including but not limited to policy briefs and documents, conference proceedings, outreach brochures, published books and relevant book chapters, public notices, reports by government agencies, and regulatory acts. The search was not limited to geographical regions. However, we could not account for documents and websites that asked for payment to access or were in a language other than English.

We considered two sets of terms – fixed and variable – for the database search. The fixed term was kept unchanged throughout, and we randomly permuted and combined the variable terms with the fixed term.

In this case, 'carbon market' was the fixed term and the variable terms were 'design principles', 'design framework', 'design patterns', 'design fundamentals', 'global principles', and 'global design principles'. To ensure the complete coverage of available documents, we used a few complimentary terms as prefixes or suffixes to a given set of fixed and variable terms. This included the following terms: 'effective', 'equitable', 'forest', 'inclusive', 'machinery', and 'transparent'. The combinatorial set was called as 'term-set' for the scope of this study. We rejected any literature that was a critique and/or contained a discussion of already considered items to ensure exclusivity across design principles.

Based on our selective 'term-sets', we identified 78 publications across search strings in each database — Academia (9), CAB Abstracts (3), DOAJ (11), Google Scholar (25), ISI Web of Science (14), JSTOR (2), PubMed (9), and Semantic Scholars (5). Numbers in parentheses represent the number of publications obtained from the databases. There were repetitions in the obtained results and we resorted to 31 unique searches. Further, we collected 28 exclusive investigatory articles and documents from the Google search engine (up to 10 pages). These 59 publications were carefully screened for eligibility based on whether the publication included information on the principles underpinning the design of a carbon credit-based market mechanism. This initial screening was done by reading the abstract (or the preface) and the conclusions, followed by reading the entire document if it was determined to be eligible. Overall, a total of 47 publications met these criteria. However, there were (secondary) publications that were critiquing and/or debating an already considered document or article. Therefore, these 47 publications were then screened for their fundamental content and to identify all the principles described in them. Among them, 30 publications were then selected after this exhaustive process which adequately represented the principles under consideration.

In this way, we shortlisted 30 design principles for carbon markets across different sectors (agriculture, energy (electricity), forests, and waste management) and geographies from the final 30 publications. We categorized them under broader classes of 10 design principles based on the similarity of meanings and descriptors and repetition of similar words within. Though the categorization is distinct, these classes are not mutually exclusive to each other and several design principles likely occur together in active carbon markets.

Identified design principles are described in *Supplementary Material S1*; the sources are shown in columns and the significant classes of design principles are written across rows. We further added three rows of information corresponding to each of the bases: the year of publication of the source material, the geographical context of the design principles, and the sector under study.

2.2. The inductive approach to classification

We identified four design principles from the ten broad classes of design principles based on the number of times that particular principle repeated itself. This inductive selection of design principles was also influenced by the context of our study - forestry as a sector and India as a geographic region were prioritized.

Out of the four shortlisted design principles, three were chosen through the maximum frequency of entries of occurrence. In decreasing order, these were governance regimes (frequency of occurrence, n = 26), efficient management of emissions, credit units, and "caps" (n = 20) and enabling a collaborative venture (n = 20). The fourth one was selected by combining two closely related classes of design principles with maximum occurrence under the forestry sector and geographic region of

India: spatial and temporal commitments (Table 1). We have tabulated the number of times a given design principle was encountered within sectors and geographical regions (Table 1).

3. Results

We shortlisted four design principles as likely tools to design and implement a market-based mechanism in a way that caters to the socio-ecological circumstances and land management regimes commonly found in India. It, however, does not infer that the rest of the design principles tabulated from the global literature are not valid. In many cases, we could derive indirect associations between each of them (Fig. 1).

Comprehensive, fair, and transparent governance regimes while developing the FCMs may likely enable long-term positive outcomes, as stressed by design principle 1. The market's effectiveness would be likely determined by its stringency in terms of a robust and consistent regulatory framework (design principle 2) that emphasizes a long-term outlook on forest monitoring and is not bogged down by short-term goals. The FCM's machinery needs to safeguard the interests of the most vulnerable actors (in this case, local forest-dependent communities who live in and have traditionally been stewards of Indian forests) and offer flexibility to comprise community-sensitive and contextual factors during implementation. Design principles 3 and 4 stress this critical aspect of collaboration and locally-relevant spatio-temporal flexibilities respectively. These 4 design principles are also summarized in Table 2.

Table 1
Overall distribution of design principles from global literature. Here, cross-sectoral refers to those carbon market design principles that were proposed for multiple sectors like agriculture, forestry, energy, etc. Non-India refers to those carbon market design principles that were for the Global South but were not specific to India.

S. no.	Design principles from Global literature	Occurrence frequency in literature (n)	Occurrence frequency of design principles per sectoral distribution	Occurrence frequency of design principles per geographic region distribution
1	Governance	26	Forestry: 8 Cross-sectoral: 18	India-specific: 3 Global or non-India: 23
2	Efficient management of emissions, credit units & "caps"	20	Forestry: 7 Cross-sectoral: 13	India-specific: 2 Global or non-India: 18
3	Sustainability	12	Forestry: 6 Cross-sectoral: 6	India-specific: 2 Global or non-India: 10
4	Enabling a collaborative venture	20	Forestry: 6 Cross-sectoral: 14	India-specific: 2 Global or non-India: 18
5	Quality of units	15	Forestry: 5 Cross-sectoral: 10	India-specific: 1 Global or non-India: 14
6	Temporal parameters	13	Forestry: 8 Cross-sectoral: 5	India-specific: 3 Global or non-India: 10
7	Supervision	16	Forestry: 6 Cross-sectoral: 10	India-specific: 3 Global or non-India: 13
8	Resonance to national and international agreements	11	Forestry: 4 Cross-sectoral: 7	India-specific: 3 Global or non-India: 8
9	Spatial parameters	8	Forestry: 6 Cross-sectoral: 2	India-specific: 3 Global or non-India: 5
10	Reconnaissance & piloting, implementation and delivery	17	Forestry: 6 Cross-sectoral: 11	India-specific: 3 Global or non-India: 14

3.1. Design principle 1: Comprehensive governance regimes

A robust governance regime draws from the basic attributes of accountability, equity, monitoring, transparency, and trustworthiness.

Previous evidence suggests that the trade of credits in FCMs may not be contributing to actual carbon removals on the ground or it may likely lead to conflict with existing socio-political institutional mechanisms (Aggarwal, 2020). On the demand side, it may rather provide an open avenue to credit buyers to distract from actual climate mitigation. For certain groups of market actors, it could likely be a 'license to pollute now and clean up later', meet artificially low emissions targets, and get an undeserved appreciation for being 'environment friendly' (Miltenberger et al., 2021). On the supply side, the planting of non-native species (Coleman et al., 2021), and tree-biased planting models (Veldman et al., 2019) cause significant social (Bayrak & Marafa, 2016) and ecological (Davidar et al., 2010) damage and undermine the integrity of the FCMs mechanism itself (Benecke, 2009).

As a response, a robust FCM governance model may focus on two components: first, clarity in applied terms and definitions, and second, transparency in the market functioning (Table S1). "Inclusive and transparent governance" was stated as the first design principle to guide the Indo-Pacific Carbon Offsets Scheme (Department of Climate Change, Energy, the Environment and Water, 2021). "Clarity of terminologies" and "transparency" were highlighted as two of the key factors to achieving a robust governance regime in carbon trading machinery (International Emissions Trading Association, 2023).

Transparency in market governance has been stressed multiple times in the G7 Ministers' Meeting on Climate, Energy & Environment (G7 Sapporo Meeting Report, 2023). According to this, accountability and clarity in decision-making processes should be two likely pillars of transparency. It should be complemented by public disclosure of likely ecological and social outcomes of market mechanism in its entirety, while respecting human rights. A healthy carbon market has to prioritize comprehensive governance regimes to likely deliver high-impact on ground actions (Stern et al., 2010). In such way, it can likely motivate the 'still-in-its-infancy' FCMs to follow similar footprints and get commendable outcomes. Assorted opinions on facets as basic as what is a "quality carbon credit" are likely deterrents to consistent governance of (voluntary) carbon trading programs (Kiwelu et al., 2022). In many cases, (forest) carbon trading systems transcend international boundaries and that calls for urgent interventions to fix such ambiguities in definitions and standards.

The first component of governance regimes is clarity in terms and definitions. Clarification of the use of the term 'forest carbon credit' itself is a key part of integrity and governance considerations. The terms for any claims regarding the generation and sale of forest carbon credits would need to be carefully developed and agreed upon by a large set of market actors. Currently, there does not exist a uniform definition of what constitutes a 'forest carbon credit'. A singular definition and framework of what constitutes one unit of forest carbon credit can greatly improve the governance of FCMs and strengthen trust in the system, and curb instances of greenwashing. Such a definition and framework may involve a governance regime that only considers those carbon removals as verified forest carbon credits that are generated in compliance with existing regulations and standards, have established carbon rights, implemented free, prior, and informed consent among local beneficiaries, have minimized uncertainties, addressed risks of non-permanence, and are monitored against a credible baseline. To further increase stringency, there may be opportunities to put reasonable control on terms like 'environment and ecologically friendly', 'sustainable', and 'climate smart', which have often been used by actors in the past to distract from demonstrating real and verifiable carbon sequestration in forests.

Second, transparency in the market functioning is imperative to

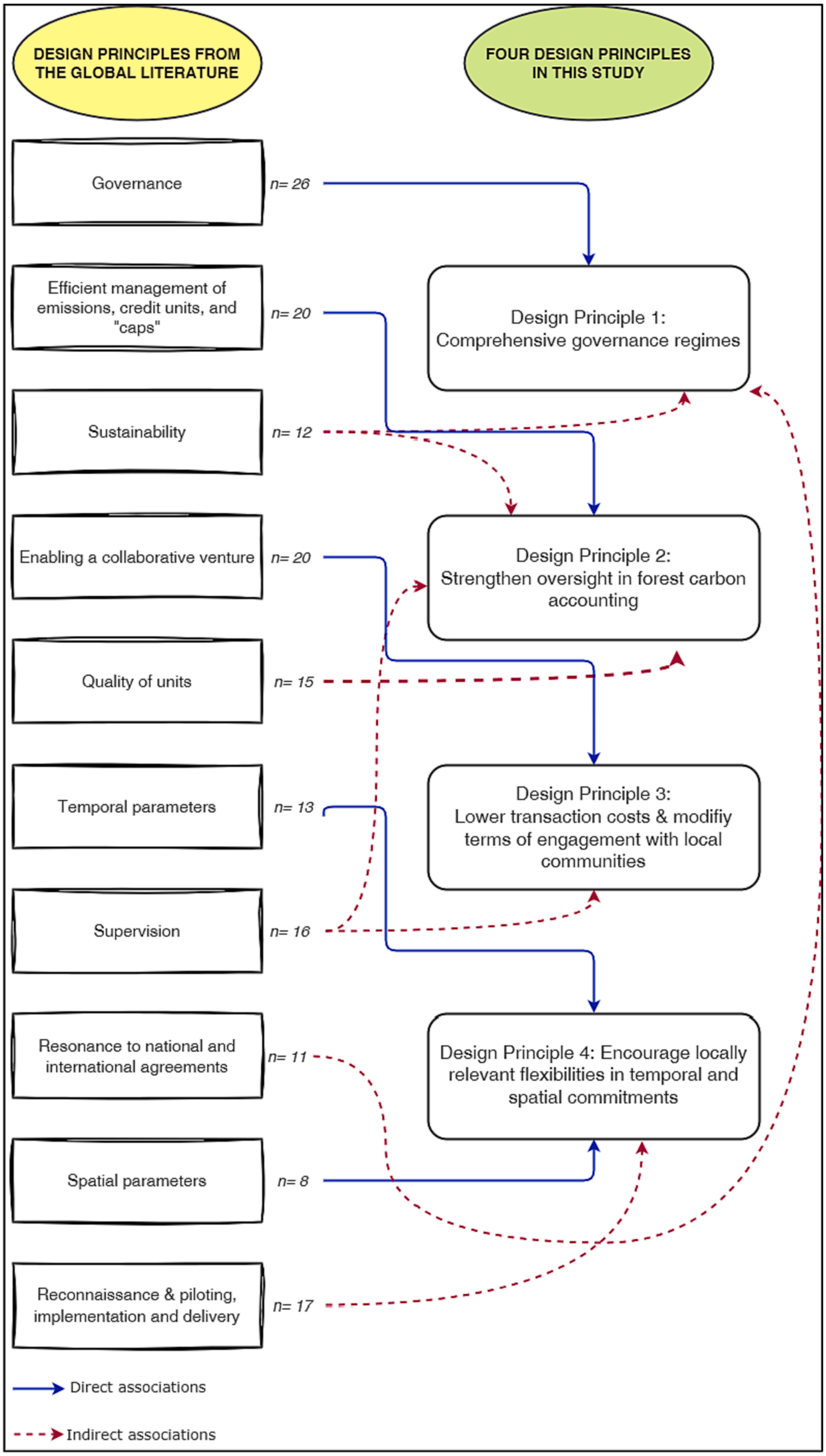

Fig. 1. Illustration to outline the occurrence frequencies of enlisted design principles from the global literature and their linkage patterns to the shortlisted design principles in the Indian context.

Table 2
Overall table collating the proposed four design principles, major components being talked about, existent gap that need to be addressed, and the respective likely actions.

S. no.	Design principle	Components	Existent gap	Actions required
1	*Comprehensive governance regimes*	1.1: Definitions and standards	Lack of consistent definitions and standards	Clarity on terms, definitions and standards
		1.2: Market functioning	Gaps between claims and on-ground realities	Formation of entities with a remit to pursue evidence-based claims and oversee on-ground implementation
2	*Strengthen oversight in forest carbon accounting*	2.1: Leakage management	Leakages outside project boundaries	Stronger pricing mechanisms and institutional oversight
		2.2: Carbon accounting practices	Double counting, additionality, non-permanence	Clearer project design (in terms of lifetime and expected outcomes) and strict monitoring and evaluation
		2.3: Integrity of market actors	Inability to deal with actors operating in bad faith	Stronger entry barriers
		2.4: Localized caps	Absence of well-quantified emissions caps in practice	Setting caps (standards) based on local contexts and capabilities
3	*Lower transaction costs and modify engagement terms with local communities*	3.1: Transaction costs	High upfront transaction costs	Upfront financing & engaging local stakeholders like local community-based organisations and *Gram Sabhas*
		3.2: Local project stewardship	Lack of involvement of local communities	Appreciation of local knowledge on forest management and monitoring mechanisms
4	*Encourage locally relevant flexibilities in temporal and spatial commitments*	4.1: Temporal flexibilities	Prolonged commitment periods	Localized flexibility in reward mechanisms
		4.2: Spatial flexibilities	Unreasonable spatial requirements	Accounting for contextual nature of forest use patterns

ensure that claims of carbon removals are supported by actual implementation and monitoring on the ground, thus removing the risk of 'greenwashing'. Moreover, forest carbon credits may only be used as complementary, not as an alternative, to real and verifiable emissions reductions in respective sectors. One way to achieve this goal may be to stress specific sectoral policies that bracket the management of intra- and inter-sector credit usage. This would restrict instances of forest carbon credits being used to compensate for emissions in unrelated sectors, as well as limit cases where there is significant geographical displacement between emissions release and emissions reductions.

Market-based mechanisms in India would also need to account for these two aspects. A centralized National Steering Committee (NSC; as mentioned in the notification of the Ministry of Power's Carbon Credit Trading Scheme 2023) may be tasked with additionally ensuring that clarity in definitions and classifications is a part of their mandate, in addition to overseeing other facets of transparency—setting guidelines for carbon credit certificates within and outside the country, deciding the (emission) target limits, determining the time parameters (like crediting period, renewal of credit certificates), and monitoring its functioning.

Besides addressing the two components of governance regimes, market-based mechanisms in India would need to devote enough importance to biodiversity values and ecosystem service provisioning to benefit local communities democratically. Related research from the Indian landscape has reported that efforts to conserve, increase or protect forests may be misdirected, for example in choosing the wrong tree species for reforestation (Rana et al., 2022). As forest carbon trading efforts may be scaled in the future, it becomes more urgent than ever to tackle the 'focus' of such projects to better inform investment decisions. If the focus is restricted to only carbon sequestration, there is a higher likelihood of developing near-monocultures of generalist and fast-growing tree species. Not only the carbon market quality would be negatively affected by such activity, but it will also lead to an ensuing disturbance of the entire landscape, both from ecological and socio-economic perspectives. Therefore, broadening the focus to allow the accrual of tangible non-carbon benefits would likely improve governance regime and integrity of the generated credits.

3.2. Design principle 2: Strengthen oversight in forest carbon accounting

This design principle is centered on evolving robust carbon accounting and pricing mechanisms for FCMs, the absence of which is now well-recognised as a barrier for upscaling FCMs across the world (Organisation for Economic Co-operation and Development, 2017).

The Global Green Growth Institute (2022) technical report emphasized on this design principle by introducing the need to "avoid double counting through robust accounting". It further said that double counting can be detrimental in attaining any NDCs since the calculations may not be accurate. A similar report from the Indian government's Ministry of Power emphasized the need to set suitable emission targets, bring in additional sectors whenever needed, to ensure sufficient demand, and avoid double counting (Mukherjee, 2023).

Niesten et al. (2002) emphasized the need to control leakage issues from FCMs and provided multiple scenarios where leakages can inflict large-scale damage to the environment. For instance, the authors considered a situation where leakage leads to an increase in harvesting within natural forests. In that case, it is likely to cause harm to the entire biodiversity of that forest scape. In another situation, net carbon release in the atmosphere is expected to increase if the leakage of timber harvests is consigned from the forests of developed nations to developing ones. For a sustainable implementation and processing of carbon market machinery, additionality must be ensured, and leakage should be strictly stressed (Institute for Sustainable Development and International Relations, 2022).

The presence of actors engaging with bad faith and conduct can have huge negative impacts on the market design and functioning (International Emissions Trading Association, 2023). Building on 20 years of experience working on voluntary carbon markets, Redshaw (2023) reported multiple actors operating in bad faith at different levels of the market system. This has been echoed by other reports that describe how actors operating with bad intentions coupled with existing flawed practices have denigrated the standards of carbon trading and affected the public's confidence in markets' abilities to deliver positive climate actions (Robo, 2023). For instance, there are cases where local communities have "signed" away the rights to carbon credits to corporate enterprises after being misguided by local intermediary agents (Dev & Krishnamurthy, 2023).

According to our review, the need to have emissions 'caps' features frequently. Such a programme is a market-type of its own, quite prevalent in the European Union (O'Kelly, 2023b). In forest carbon trading settings, a cap and trade program would likely warrant that emitters, who exceed their permissible emission limits, have to pay a certain forest land owner(s) to sequester carbon (by purchasing verifiable carbon credits) (Daniels, 2010).

Therefore, we describe four components making up this design principle to respond to these discussions. First, we find that leakage is the primary concern reflected in the literature. Second, improper auditing practices such as double counting, additionality, and permanence are key factors that negatively influence the evolution of efficient pricing mechanisms within FCMs. Thirdly, there is a need to account for actors operating in bad faith. Daniels (2010) indicated that these factors are "concerns that must be addressed" to obtain real and verifiable forest carbon credits. Finally, evolving caps on trading remain a viable way to restrict emissions and better govern carbon trading (Neeff & Ascui, 2009).

To begin with, there are leakages in the functioning of FCMs that may often be overlooked. Examples include a forest conservancy project that avoids the emissions caused by clearing one parcel of forest area but displaces deforestation to other areas. In certain circumstances, FCMs shift reductions from developed to developing nations; precisely, where it is cheaper to reduce, with emissions at one place and removals at another considered equivalent. A stronger pricing mechanism is likely to control the leakages in FCMs wherein an entity found to be shifting reductions has to pay much higher prices– decided at local, national, and international levels depending on the project specifications.

Second, the FCM system has also attracted enough negative attention due to instances of improper financial accounting and fraud in carbon credits trading (Chêne, 2010; van Kooten, 2017). Double counting is often reported where, as the name suggests, two different credit buyers claim the same carbon removal or reduction credit. Further, there remain concerns around 'additionality'. Evidence suggests that several forest carbon projects claim carbon removals that would have happened anyway in the absence of the said project because of the identified forest being under no real threat from conversion or was already under protection. There are project-specific crediting baselines (or baseline emissions) in the FCMs that act as references to calculate GHGs reductions and are closely tied to additionality. Permanence is a kind of sustainable obligation of a high-integral FCM where carbon stored by a forest carbon project must be maintained for a chosen period and the inability to meet that obligation leads to the disqualification of generated credits.

Recent literature suggests that additionality is close to zero in one of the most highly regulated carbon markets (like California's) (Badgley et al., 2021; Badgley et al., 2022; Coffield et al., 2022), while other studies suggest leakage rates regularly exceed 50 % and often reaching close to 100 % largely due to factors beyond the control of local project developers (Filewood and McCarney, 2023). At times, having appropriate baselines cannot be a sufficient solution to avoid additionality, more likely when FCMs have to deal with spill-over effects into other jurisdictions.

For such cases, Filewood and McCarney (2023) proposed three principles to arrest additionality (and leakage) through design modifications of the market system. Firstly, they suggested that "any nature-based solutions (NbS) that are reducing GHG emissions should not be treated as substitutes for avoided emissions and be regarded as discrete entities" in market transactions. The authors believe that this principle would seize the chances of additionality more in the context of protected areas (such as conservation reserves). Secondly, they recommend that "The standard of certainty for avoiding market leakage risk should be set by the nature of the substituted action". This holds more relevance in the voluntary FCM settings where for-profit organizations and corporate industries fund forestry activities to claim carbon offsets as tools to present positive climate action. In such cases, the nature of the carbon offsets (here, the substituted action) should be carefully considered to determine the standard of certainty. Thirdly, the authors endorsed "use of upper-bound estimates when there is a probability of leakage in the FCM projects". Though the authors have argued the applicability of this principle may be likely unrealistic considering small-scale FCMs, they still believed that this conservative-design-based approach along with the second principle can check on additionality and maintain auditing integrity.

Further, remote sensing and GIS (RS-GIS) approaches can likely be better enablers in auditing and monitoring. These tools can supplement field-based data collection and monitoring. Cunningham & Montgomery (2011) reviewed the contributions of RS-GIS tools such as LiDAR (Light Detection and Ranging) and SAR (Synthetic Aperture Radar) in carbon (biomass) estimation in forest parcels and its applications in FCMs. While remotely-sensed data needs regular ground-truthing, its use as a complement to ground-based monitoring, especially at scale, remains very promising (Cunningham & Montgomery, 2011). For example, emerging initiatives like Open Forest Protocol, which combines ground and spatial data, provides a monitoring approach for land parcels as small as 0.3 ha.

Third, at times, actors operating in bad faith (Swiss Network for International Studies, 2021) may engage in illegal and unethical practices, undermining the functioning of FCMs. For example, this may occur through incidents where local communities are coaxed into signing technically inaccessible legal contracts which transfer their land rights to other non-local entities. The design principle, therefore, suggests adopting strong regulatory framework that would likely promote vigilance and regulation of the market system to render localized and broader reliability and effectiveness. Besides manifesting a firm control over such wrong actors, this can entail standardized norms-based scrutiny to ensure that the carbon credits fulfill certain necessities before being released in the market transaction. The role(s) of this regulatory framework would likely be three-fold: direct the flow of resources and information, support implementation, and maximize positive outcomes.

Besides keeping a check on actors operating in bad faith, in practice, this regulatory framework may take several forms in the Indian context. For example, emissions from tropical deforestation are immediate, irreversible, and significant in a realistic timeframe for climate change this century, while afforestation projects take decades to give equivalent benefits. Keeping this in mind, a framework that prioritizes credits originating from the conservation of standing forests, rather than those which aim at afforestation and/or reforestation is more likely to be effective in its objective. The government may also restrict the generation of forest carbon credits from certain high-quality forest areas (in terms of forest areas with high carbon stock areas, high biodiversity conservation values, or high cultural values) and biodiversity hotspots, to avoid potential conflicts of interest and safeguard the ecological heritage of the nation. In addition, the framework may have a stated goal of maximizing co-benefits and minimizing trade-offs in forest carbon sequestration. Since forest ecosystems are known to provide provisioning and regulating ecosystem services, a forest carbon credit may only be considered real and verified if there are demonstrable co-benefits to groundwater levels, biodiversity conservation, etc.

Fourth, determining localized "caps" in emissions trading may be useful in achieving market objectives (Organisation for Economic Co-operation and Development, 2017). In the private sector, this could take the form of emitters needing to comply with a minimum carbon reduction target and then trade emissions both nationally and internationally (Srivastava & Swain, 2022). However, international trade of carbon credits would likely seek more regulatory policies that are beyond the purview of this paper.

3.3. *Design principle 3: Lower transaction costs and modify terms of engagement with local communities*

This design principle calls to build healthy partnerships across different actors and agencies to likely deliver effective and equitable FCMs and holds strong relevance in the Indian context considering the historical role of local stewardship in forest conservation and management. The growing traction of FCMs as likely instruments to acquire critically needed finances for sustainable forest management initiatives is possible through collaborating with the perspectives of local stakeholders (like NGOs and local communities) (The Forest Carbon Partnership Facility, 2021).

Local communities are recognised as the “most effective forest stewards” in FCMs and related transactions (Kantecheva, 2023). Ahonen et al. (2022), in their article on examining the emerging features of international carbon market governance, argued the need to have ‘stakeholder consultation and grievance redressal mechanism’ to encourage local collaboration. In the UNEP (United Nations Environment Program) report, Chenost et al., (2015) resonated in a similar tone while discussing forestry programs and FCMs (pp. 14), “The strength and success of these projects, and the role they will play in the future, are dependent upon collaboration between both public and private initiatives”. Mehling (2009) realized the need to bear accountability among market participants and safeguard their interests to facilitate a collective venture of carbon trading. Through a study across 40 villages and towns in India to examine how carbon trading works, it was revealed that local communities and their lands and labour are central to the market’s healthy functioning and still they are mostly unaware of their contributions and rights (Dev & Krishnamurthy, 2023).

The question then arises of what inhibits the participation of local communities in market mechanisms. Therefore, through this design principle, we find it imperative to first identify the likely reasons for the lack of participation of the local forest managers and offer solutions to achieve widespread participation among actors.

High upfront and transaction costs in accessing the FCM remains the most significant barrier for small-scale forest carbon projects. Pearson et al. (2014) defined transaction costs as ‘financial charges to define, establish, maintain, and transfer carbon credits’ and calculated the range of estimated transaction costs as 0.3 % to 270 % of anticipated income based on carbon credit(s) prices and project size. In countries with good forest productivity, high transaction costs could dissuade the establishment of carbon sequestration projects and this is often due to the poor quality of the trading ecosystem (Grafton et al., 2021). High transaction costs are directly related to the increase in participation costs and reduction in economic exchange gains (Milne, 1999). Dudek & Wiener (1996) categorized the transaction costs into search costs (costs of tracing interested forest managers for partnering), negotiation costs (costs associated with dealing and drafting agreements), approval costs (costs of time delays between submission and approval of project details), monitoring costs (costs of regular project assessments), enforcement costs (costs of assuring that the market partners are abiding by the legalities), and insurance costs (costs of indemnity for project failure). The contextual market situation would likely determine which transaction cost category would be higher. For example, Lile et al. (1998) presented a case study of carbon market development in the Czech Republic from the 1990s when approval costs were the highest while Pearson et al. (2014) referred to insurance costs being the highest at present due to public uncertainties about the success of market mechanism.

Lowering these transaction costs would require some kind(s) of subsidy - the most likely way to do this would probably be to price every credit higher than what it is currently — the average price of a forest carbon credit, at present, ranges from USD 30–50/tCO_2 (United Nations Environment Programme, 2023).

From the Indian perspective, community-owned and/or community-managed forests constitute a significant share of the total forestlands that may come under a market-based mechanism. Here, the transaction costs may not necessarily be only financial in nature but also involve asymmetry in information, especially after the modest success of the Forest Rights Act (Aggarwal, 2018). Local people may not be fully cognizant of market functionalities, disincentivizing participation and acting as a key barrier to being equitable and inclusive. There is also evidence that carbon projects can be particularly difficult for people to understand given the rather abstract nature of the goods being marketed (Christiansen et al., 2023). Addressing such transaction costs may likely determine if FCMs can enable significant forest carbon removals in India (Cacho et al., 2013).

Ultimately, it is necessary to treat the local communities as active partners and not passive beneficiaries, valuing their diverse cultural practices in forestlands, and respecting local belief systems and traditional knowledge. In practice, this may involve the design and development of innovative compliance and monitoring mechanisms. This could, for example, take the form of peer-to-peer enforcement approaches or community monitoring systems. Local institutional members from *Gram Sabha* or sub-district offices can be trained to monitor the projects as an alternative to third-party audits. Approval costs can be reduced by easing the institutional protocols wherein a time limit is set for the approving committee/chairs to announce their decisions.

In general, it is expected that as market-based mechanisms gain traction in India, more operational entities are likely to enter the market machinery lowering the transaction costs for individual projects. Routine monitoring of fund movements through decentralized monitoring mechanisms would likely add to the effectiveness of the mechanism at local levels. Further, the market structure will possibly be more inclusive if the concept of regulatory incentives can be pooled in, and that collectively engages with the market. This can likely be in some form of regulated rewards to local actors who take charge of certain responsibilities like capacity building, or monitoring, etc. Negotiation costs are the initial investments and can be possibly lowered with legally-binding contracts stipulating the payment amounts and conditions. These efforts may even be facilitated by local community-based organizations and may substantially decrease registration, monitoring, and verification costs. While transaction costs have been known to decrease with an increase in project size significantly (Galik et al., 2009), this may not be possible in India where forests occur in a mosaic of land use and ownership on the ground. In such cases, upfront financing could likely incentivize (small-scale and financially-disadvantaged) local communities to be a part of carbon trading projects.

3.4. Design principle 4: Encourage locally relevant flexibilities in temporal and spatial commitments

This principle identifies a key point in the Indian context here — the need to have certain minimum requirements on the spatial extent and temporal commitments to be eligible to participate in the FCM mechanism. These factors, along with another restrictive factor of the ‘nature of land use’ may adversely affect the participation of local communities.

Previous literature has recognized this aspect as a key barrier. In fact, authors have separately investigated the spatial and temporal issues (Fankhauser & Hepburn, 2010a, b). They opined that the long commitment periods in carbon trading are common, but they should be providing room for situational flexibility (Fankhauser and Hepburn, 2010a). For the spatial issues, they suggested the need to consider the contextual socio-political and governance background (of the place) and offer flexibility accordingly (Fankhauser and Hepburn, 2010b). Hingne (2018) stressed the aspect of ‘flexibility’ in these factors to welcome more participation from the local forest managers. In the report on guidelines for developing domestic carbon crediting mechanisms, the authors realized that the temporal issues fall as one of the core elements of the carbon trading mechanism, “Policymakers also need to decide on the length of the crediting period (i.e., the time during which a project is registered and for which credits can be claimed).” (World Bank Group, 2021; pp. 4).

Actors may hesitate to engage in the FCM systems due to the multi-generational lengths of contracts and the restrictive nature of commitments typical of forest carbon projects (Parisa, 2021). At the same time, spatial thresholds (for participation and profits) and restrictions on land use type limit participation to a significant extent (Locatelli & Pedroni, 2004). In the Indian context, it is conceivable that local communities may set aside a section of the forests they manage while continuing to seasonally cultivate in other sections, a practice common in regions where shifting cultivation may still largely be practiced. However, stringent regulations governing the use of forests may not permit that.

Flexibility within the market structure to incorporate diverse spatial, temporal, and use contexts would be more likely in generating high-quality forest carbon credits. This would involve the capacity of the market to absorb the diversity of India's ecosystems, land use, and land tenure. Forests in India extensively cater to use by local communities and occur in a mosaic of agricultural and other land uses. There exist very few patches of unused and contiguous forests outside protected areas. These forest land use systems are supplemented by agroforestry systems, which make up approximately 8.2 % of the total land area in the country (Mathur et al., 2022). Therefore, FCMs would necessarily have to account for the contextual nature of forest land use in India. Approaches that account for the presence of mosaic forest patches and can adjust for generating carbon credits from diverse land use systems such as agroforestry, silvopasture, agro-silvopasture, etc on a case-by-case basis would be more likely to be effective.

Carbon sequestration is a slow process and forest carbon credits take years or decades to accrue. This time lag between the initiation of the activity and the generation of credits could likely be addressed through flexibility in reward mechanisms. This could take the form of preferential sourcing of carbon credits from local community-managed forests to reward early action, especially in cases where rewarding early action may be beneficial, or where projects adhere to robust criteria and demonstrate exceptional benefits to local people and/or biodiversity. Commitments to forward finance and/or forward credit purchases can contribute to incentivizing an accelerated and increased supply of such credits. It would likely be more effective with local and national government interventions– providing policy certainties and safeguards to instill faith and increase trust through strengthening legal, regulatory, and accounting systems among local communities so that all participating actors have shared long-term objectives in mind.

4. What are the challenges that FCMs may encounter in India?

In theory, FCMs have been identified as a means to channel resources toward effective climate action by incentivizing forest protection and expansion (Laurance, 2007; Fleischman et al., 2021). While they may be voluntary with some form of regulatory control, one of their key objectives is to fill existing gaps in public forest governance. Market-based conservation approaches would only be successful if they allow, and even promote sustainable forest use by local communities. Sustainable use has been known to be effective in achieving conservation outcomes (Campos-Silva et al., 2021) while such use can also help advance other well-being objectives among local communities, thereby ensuring that finance flows are truly transformative. Emerging literature, both academic and investigative, suggests that FCMs have only had modest success, especially in the tropics (Grafton et al., 2021) while tropical deforestation has continued at alarming rates (Curtis et al., 2018; De Sy et al., 2019). Moreover, if designed and implemented poorly, market-based conservation approaches that do not consider the interests and well-being of local communities can increase conflict between local communities and government agencies and fail to achieve intended outcomes (Armitage et al., 2020; Höhl et al., 2020; Schmid, 2022).

In this context, there are three primary challenges that FCMs may encounter in India: (i) Land property rights; (ii) Implementation capacity; (iii) Fundamental flaws in carbon markets themselves. These challenges are explained briefly below.

Firstly, explicit land rights/secure land tenure are basic prerequisites for a healthy functioning of the carbon market mechanism (Gonzalo et al., 2017) such that land managers can be financially incentivized to conserve forests. Design principles 1 and 3 also address this aspect. In India, however, competing interests and land ownership disputes undermines the determination of who gets to decide forest land use and who gets to benefit from it under the market mechanism. On the one hand, state-governed forest departments are the legal owners of an overwhelming majority of Indian forestlands with managerial power in revenue generation (Talukdar et al., 2021). They have significant regulatory and governance authority, although their record in effective forest management and working with local communities has come under considerable scrutiny in several Indian states (Hill, 2000; Coleman et al., 2021).

On the other hand, the forest land rights of local community groups are legally ambiguous in many cases. The Forest Rights Act 2006 aims to rectify this, albeit has only had mixed success to date (Aggarwal, 2018). In this context, conflicts between these communities and forest departments (Kumari et al., 2020) and internally within the communities are also common, and revolve around how forest areas may be governed and used. Decades of sub-optimal outcomes from the Joint Forest Management (JFM) program are evidence of this situation (Guleria & Vaidya, 2015). With such disparate interests, it may be difficult to design a benefit-sharing mechanism that caters to both forest conservation and human well-being outcomes.

Concerning implementation capacities, past Indian forest sector reforms have yielded very mixed results due to the combined impacts of limited government capacity and land conflicts (Fleischman, 2016; Lélé & Menon, 2014; Springate-Baginski & Blaikie, 2007). Research on the inclusion of forest carbon offsets in carbon markets elsewhere indicates that typically such initiatives tend to lower carbon prices, increasing the appeal of carbon markets to regulated entities (Cullenward and Victor, 2020). However, in the case of India, given the unequal power of state forest departments relative to local communities, designing effective market-based mechanisms that share the benefits from participation with all relevant stakeholders remains a significant challenge. Evidence from CAMPA (Compensatory Afforestation Fund Management and Planning Authority) Act also suggests this to be the case (Bhan et al., 2017; Pati, 2023). A principle that mandates checks and balances on executive power and the independent participation of local community groups (Design Principle 2) would be likely be more effective in transferring benefits from FCMs in an effective and just manner.

Lastly, some fundamental problems have been observed in both the theory and function of FCMs. Recently, Dev & Krishnamurthy (2023) indicated that voluntary carbon markets, in their present form, may not be leading to expected benefits for local communities and may, in fact, be increasing carbon emissions rather than limiting it. From an ecological perspective, there exists limited context-specific knowledge on the carbon sequestration potentials in diverse Indian forest types (Salunkhe et al., 2018). Such a knowledge gap, combined with the need to compare observed carbon sequestration rates with hypothetical counterfactuals, presents significant challenges to monitoring and verification as well as results-based payments under the market mechanism. In addition, FCMs are based on incentivising forest managers to change their behaviour and work towards a specific outcome (in this case, protection to maximise carbon sequestration). In the Indian context, it is not clear whether market approaches can yield similar outcomes since government entities may not act as utility-maximizing economic agents. In this case, it may be that future market-based mechanisms in India face significant challenges in working in publicly-owned land (Anderegg William et al., 2020; Badgley et al., 2021; Badgley et al., 2022; Coffield et al., 2022), and may much rather cater to community-owned forests or pursue agroforestry-based carbon removals on individual farmlands.

5. Conclusion

In this paper, we discussed the key learnings derived from global approaches in designing carbon markets to build four cohesive design principles tailored for the development of an FCM in India. These design principles seek to prioritize governance aspects, efficient management of FCM deliverables (caps, credit units, and emission units), local collaboration, and subjective spatio-temporal and land use (tenurial) relaxations. We discuss how these principles may be operationalised in the Indian context. We also find that the establishment of FCMs in India would face three major challenges rooted in current forest management regimes. By bringing together design principles with on-ground implementation challenges, this paper offers a baseline in understanding how FCMs can be developed in India and similar tropical places where similar challenges exist.

CRediT authorship contribution statement

Anirban Roy: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Resources, Visualization, Writing – original draft, Writing – review & editing. **Manan Bhan:** Conceptualization, Data curation, Investigation, Methodology, Project administration, Resources, Supervision, Validation, Visualization, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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Appendix A. Supplementary data

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