UNIVERSITY of York

This is a repository copy of *Financing Forest Restoration:The distribution and role of green FinTech in nature-based solutions to climate change*.

White Rose Research Online URL for this paper: <u>https://eprints.whiterose.ac.uk/id/eprint/226033/</u>

Version: Accepted Version

#### Article:

Liu, Felicia Ho Ming, Thompson, Benjamin S and Harris, Jack L (2025) Financing Forest Restoration:The distribution and role of green FinTech in nature-based solutions to climate change. Finance and Space. pp. 159-187. ISSN 2833-115X

https://doi.org/10.1080/2833115X.2025.2502343

#### Reuse

This article is distributed under the terms of the Creative Commons Attribution (CC BY) licence. This licence allows you to distribute, remix, tweak, and build upon the work, even commercially, as long as you credit the authors for the original work. More information and the full terms of the licence here: https://creativecommons.org/licenses/

#### Takedown

If you consider content in White Rose Research Online to be in breach of UK law, please notify us by emailing eprints@whiterose.ac.uk including the URL of the record and the reason for the withdrawal request.



eprints@whiterose.ac.uk https://eprints.whiterose.ac.uk/

# Financing Forest Restoration: The distribution and role of green FinTech in nature-based solutions to climate change

Authors: Felicia H.M. Liu\*<sup>1</sup>, Benjamin S. Thompson<sup>2</sup>, Jack L. Harris<sup>3</sup>

Affiliations: <sup>1</sup>Department of Environment and Geography, University of York, York, UK, <sup>2</sup>School of Social Sciences, Faculty of Arts, Monash University, Melbourne, Australia, <sup>3</sup>Department of Geography and Resource Management, Chinese University of Hong Kong, Hong Kong, China

\*Corresponding author: felicia.liu@york.ac.uk

### Abstract

Financial technology (FinTech) is purported to reform 'traditional' finance by expanding avenues of investment while offering a more democratic, inclusive, and transparent system of capital. Proponents have highlighted the importance of 'green FinTech' in supporting climate finance, which is currently underfunded and mired by greenwashing controversies. However, little is known about the geographies of green FinTech, the directions and effects of various investment flows, and the mechanisms through which FinTech could contribute to more socially just and environmentally sustainable finance practices. This paper assesses the growing 'FinTech for Forests' (FFF) agenda, whereby FinTech platforms use a variety of mechanisms to enable users to contribute to tree planting. Tree planting is a nature-based solution to climate change that can contribute to global forestation and carbon removal targets. Through network and content analysis, we map the distribution of FFF companies, their customer bases, funding flows, and planting locations. We highlight the key opportunities of FFF in enhancing inclusivity and democratic choice for everyday consumers to engage in the funding and decision-making of tree planting, but also reveal the limited extent to which FFF has fulfilled these 'promises'. Our intervention contributes to broader debates about whether and how an emergent digitisation and sustainability agenda reconfigures global financial networks to meet the challenges of the Anthropocene.

**Keywords:** Biodiversity finance; Carbon finance; Climate finance; Forests; Green finance; Investment; Restoration; Sustainable finance

JEL Codes: G23, Q23, Q56, Q57, O33

### **1. Introduction**

Finance is swiftly moving into the digital realm (Lai and Samers 2021; PwC 2016; Wojcik 2021; Zavolokina et al. 2016), with financial technology (FinTech) deemed particularly disruptive of 'traditional' configurations, flows, and practices of finance (Kaal 2016; World Bank 2022). In the face of climate and other environmental challenges, the promise of unlocking new avenues of financing in a more inclusive, democratic, and transparent form of trading and investment is particularly appealing for both industry and policy-makers alike (Arner et al. 2020; Suri and Jack 2016; Vergara and Agudo 2021). Despite this growing excitement for FinTech to help reach net-zero targets and overcome perceived limits of green finance (Menon and Jain 2021; Nishant et al. 2020; Patterson 2023), applications of green FinTech - the deployment of FinTech to to drive green finance (see also footnote 3) - to address environmental challenges have seldom been studied.

In this article, we focus on FinTechs providing a novel financial service that enables retail and enterprise users to fund tree planting through everyday financing and transactions. Tree planting activities are proliferating globally as a nature-based solution to climate change (Mansourian et al., 2022), as the resulting forestation can contribute to carbon sequestration and ecosystem restoration (Di Sacco et al., 2020). In this article, we will be using 'tree planting' and 'forestation' interchangeably. Tree planting results in 'forestation' (increasing the number of trees) either through 'afforestation' (planting on land that did not have trees previously) and 'reforestation' (planting on deforested land that did once have trees). While we acknowledge that tree planting is an activity that can lead to 'forest restoration', this is not the case if it is done poorly; for example, by planting monocultures that lack the biodiversity and ecological functioning of healthy and established forests. Notably, the Trillion Trees Initiative exemplifies growing interest in deploying this deceptively simple mechanism to reverse the negative consequences of climate change (Seymour 2020). However, tree planting requires substantive initial cost to implement and scale (Austin et al. 2020; Brancalion et al., 2019). Subsequent maintenance costs are equally high (Fleischman et al., 2021; Löfgvist and Ghazoul, 2019; Rana and Varshney, 2023). Amid the broader macro political-economic landscape of austerity that limits traditional channels of public funding, environmental initiatives and climate solutions is increasingly being monetarily supported through private, marketised approaches such as various iterations of 'climate', 'green' or 'sustainable' finance<sup>1</sup> instruments and products (Evans, 2018; Fleischman et al., 2021) - akin to other international sustainable development agendas (Gabor 2021). The emergence of FinTech solutions to forestation represents the latest development to this finance-centric paradigm of climate politics.

The emergence of FinTechs that integrate tree planting into their business models, branding, and operation costs signals that innovative 'FinTech for Forests' (FFF) efforts are underway to help fulfill this requirement (d'Orazio et al., 2024). As such, we aim to investigate how FinTech impacts the effective and equitable scaling of forestation via tree planting. Our objectives are to: (1) map the distribution of FFF platforms and their funded tree planting activities, and (2) scrutinise the extent to which this distribution and its governance structures

<sup>&</sup>lt;sup>1</sup> There is general consensus that climate finance, green finance, and sustainable finance are related but distinct concepts. Climate finance specifically refers to funding allocated for climate mitigation or adaptation activities; green finance is broader and encompasses financial instruments that support the environment; while sustainable finance has the widest scope, integrating environmental, social, and governance (ESG) considerations into investment and financial decision-making (ICMA 2020).

have increased financial flows, inclusivity, democratisation, and transparency in forestation. Our motivation is neither to endorse nor reject the necessity of FFF in facilitating global forestation and climate goals. Rather, we seek to (1) investigate this prevalent development trajectory in the forestation and green finance sector, and (2) critically evaluate the various claims that are made about the potential of FFF in overcoming the perceived limitations of traditional (green) finance. By doing this, we also meet broader calls to scrutinise the extent to which FinTech can facilitate additional capital flows towards addressing environmental objectives (e.g. Awais et al. 2023; Liu et al. 2022; Udeagha and Ngepah 2023; Zhou et al. 2022).

Studying FFF bears broader implications for mapping new production patterns enabled by FinTech (Wojcik 2021), particularly as the financial system attempts to achieve the 'twin transition' of digitisation and decarbonisation (Kovacic et al. 2024). While FinTech applications are often perceived as abstract and virtual, Zook and Blankenship (2018) have highlighted how FinTech is embedded within environmental material realities such as land and energy use. By turning attention to an application of FinTech designed to generate positive environmental impact, this study explores how FinTech's production and consumption shapes new models of value creation and environmental outcomes. By examining FFF, we gain insight into how digital finance is not only reshaping financial landscapes but also reshaping material realities in the environment.

The remainder of the article will be structured as follows. Section 2 presents four key 'promises' envisioned by the proponents of FinTech to reform financial configurations and practices. Section 3 explains our research methodology. Section 4 presents our findings on the spatiality of FFF, and critically analyses existing FFF initiatives against the aforementioned four 'promises'. It then discusses how the four 'promises' of FinTech bear uneven opportunities and challenges when materialised in the context of tree planting. Section 5 concludes the article with recommendations for key stakeholders involved in the FFF value chain.

## 2. How can FinTech 'Green' Finance?

### 2.1 The Global Forestation Challenge

In the face of growing interest in forestation as a nature-based climate change mitigation strategy (Seymour 2020), there has been no shortage of 'green finance' attempts to address the global (de)forestation challenge. Several financial mechanisms have emerged in the last few decades to generate capital for forestation projects. Notably, Reducing Emissions from Deforestation and Forest Degradation (REDD+), a global framework under the United Nations Framework Convention on Climate Change, has emerged as one of the most prominent financial mechanisms to channel finance towards sustainable forest management, conservation, and enhancement of forest carbon stocks - albeit with limited evidence of success (Duchelle et al., 2018). In particular, the governance and verification of REDD+ projects have come under intense scrutiny, with claims that many projects have negatively impacted local people (Chomba et al., 2016; Dawson et al., 2018), while not significantly reducing deforestation (West et al., 2023). Other green finance instruments such as green bonds have subsequently emerged, yet faced similar criticism (Thompson, 2022). Other tree

planting programmes financed by 'traditional' means - such as through national government budgets - have also failed to increase forest cover or improve the livelihoods of local people (Cao et al., 2010; Coleman et al., 2021).

Existing financial mechanisms are typically driven by highly technocratic discourse that masks the underlying politics and overlooks the environmental material realities created by such investments (Baird and Green 2020; Milne and Mahanty 2019; Pye 2019), and provide limited accountability for financiers by the public, let alone impacted communities, when projects have negative socio-environmental consequences. While tree-planting guidelines have emerged in attempts to address the issue of missing community empowerment and representation (Brancilion and Holl, 2020; Di Sacco et al. 2020), they tend to be too generalising, failing to acknowledge issues of power imbalances, land tenure conflicts, and the equitable distribution of costs, risks, and benefits (Elias et al. 2022). Scrutiny over forestation projects - from location selection or partnership governance, to socio-economic impact - is due (Holl and Brancalion 2022). The repeated failure of many financial mechanisms to address these complex concerns and promises from green FinTech to provide a solution underscore the importance of our intervention.

Critical scholars further highlight the inherent contradiction in using financial mechanisms to address climate and environmental issues that speculative and extractivist capitalist activities have played a significant role in creating (Cohen et al. 2022). By rebranding financial instruments as 'innovative' and 'green', the financial sector reinforces profit-maximising and rent-seeking logics while hindering more radical approaches to transitioning to a low-carbon economy (Knuth 2018). Political ecologists pointed out the perverse logic behind the commodification and marketisation of nature (Sullivan 2013). It is argued that this imposes financial logics and tactics onto local ecosystems and communities (Dixon and Challies 2015; Pye 2019), and creates misaligned incentives that lead to environmentally and socially negative outcomes, such as continued environmental destruction, land grabbing (Ingalls et al. 2018; Milne and Mahanty 2019), displacement of local communities (Carter et al. 2017; Ingalls et al. 2018), and the marginalisation of local livelihoods (Baird and Green 2020; Dempsey 2016; Milne 2022). Moreover, forestation projects are often implemented in less economically developed countries where the cost of land and labour are lower (Brockhaus et al. 2021), while powerful corporations and financial institutions-primarily based in more economically developed countries—can 'purchase' their right to continue to pollute and destroy (Sullivan 2013).

Thus, marketising and financialising forest conservation and restoration is deeply politically laden, where the seemingly neutral and mundane design of market mechanisms in fact reflect and reinforce unequal and exploitative economic structures (Bracking 2012, 2015), while embedding capitalist elites' visions of planetary future (Bryant and Webber, 2024). Taken together, these dynamics reinforce power imbalances, where conservation priorities set by the developing countries dictate natural resource management, often to the detriment of local communities (Neumann 2004).

Nevertheless, these critical perspectives are currently juxtaposed against a prevalent agenda from policy and finance elites envisioning tree planting as a viable and desirable climate solution. Our aim, therefore, is to critically evaluate whether and how FinTech can be a solution to some of these outstanding concerns.

### 2.2 The Four 'Promises' of Green FinTech

Proponents of green FinTech promise to 'disrupt' the financial system and resolve some of the deep-rooted issues of finance in four key ways. We will critically assess the 'promises' in turn.

First, proponents of green FinTech expect it to **increase investment** in sustainable assets and projects (e.g. DAI Magister 2023; European Merchant Bank 2023). Mainstream financial institutions face significant gaps in funding climate and environmental goals due to limited scalable project pipelines (Löfqvist et al., 2023), unreliable economic and environmental impact reporting (Thompson 2022), and ineffective investor-project matchmaking (Löfqvist et al., 2023). FinTech aims to address these issues initially by diversifying investment platforms (Mollick 2014) and innovating new financial products (Nassiry 2018). However, the novelty and unfamiliarity of FinTech to investors and regulators can hinder growth. For instance, despite rapid expansion, FinTech in Latin America remains marginal, failing to disrupt the concentration of power in a handful of banking incumbents (loannou and Wojcik 2022). Indeed, the initial FinTech excitement may fade due to high profile cases of fraud undermining market integrity (Omarova 2020).

Second, green FinTech is envisioned to enhance inclusivity for both investors and entities seeking financing. For projects struggling to secure traditional/institutional financing, FinTech may open up new and/or cheaper capital access (Langley and Leyshon 2021). For example, FinTech can support capital-intensive carbon reduction projects (Macchiavello and Siri 2022) and enables environmental assets, like forest carbon projects, to be traded as digital assets (Díaz et al. 2023; Flowcarbon 2023; Hua et al. 2020). For investors, it provides new avenues to invest in accordance with their preferences (Buchak et al. 2018; Buttice and Vismara 2022), which are increasingly climate- and environmentally-oriented (Harasheh et al. 2024). For example, equity crowdfunding connects enterprises with diverse investors, even for micro investments (Cai 2018). Furthermore, some FinTech platforms have integrated algorithms with behavioral science and digital marketing to enhance user experience (Lai 2020; Lai and Langley 2024), which could both educate and allow everyday users to engage with 'green finance' with ease. However, while unprecedented access to financial services enhances inclusion, it also introduces new vulnerabilities, such as increased indebtedness (Bateman et al., 2019). Similarly, this improved 'inclusivity' may be veiling exposure to new risks that investors are not fully understanding due to weak client risk-tolerance regulations (Restoy 2019). Regulatory gaps in the FinTech sector can exacerbate these risks, leaving users of FinTech platforms exposed to predatory lending or disproportionate risks. Therefore, depending on the type of financial service and product made available, FinTech could, in fact, be replicating systems of repression and exploitation, in addition to creating new types of exclusion or vulnerabilities (Bateman and Maclean 2017; Bernards, 2019, 2022).

Third, and in relation to the second promise, FinTech is expected to **democratise** finance by redesigning market structures and business models to be more user-centric (Anagnostopoulos 2018; Arner et al. 2020; Cumming et al 2021). Unlike 'traditional' finance which relies heavily on rigid structures of intermediaries to facilitate financial transactions, the digital operation of FinTech opens up new configurations of financial organisational structures and inter-firm relationships (Lai 2020). This includes more 'user-centric' platforms that enable consumer choice (Lai and Langley 2023). Moreover, FinTech firms are often highly specialised

(KPMG 2015), providing both investors and enterprises seeking financing a greater level of flexibility to choose how and where they wish to invest (or seek investment). However, the democratisation potential of FinTech could be undermined if certain types of users dominate the governance and/or decision-making of FinTech platforms. Aside from general skepticism regarding whether cryptocurrencies can achieve their purported capacity to decentralise corporate platforms (Zook 2023), existing and new biases can be embedded in algorithm-based credit assessments and underwriting (Rizzi et al. 2021). Gamification, while engaging (Kim and Werbach 2016; Lai and Langley 2023), raises ethical concerns like data privacy and financial trivialisation. Moreover, related to concerns about creating new financial vulnerabilities, the democratisation potential of FinTech could be limited by the lack of digital access, digital literacy and regulatory uncertainties.

Fourthly, FinTech is claimed to enhance **transparency** by improving corporate oversight and governance. Big data and IoT enable precise tracking of environmental risks and impact, while smart contract-enabled blockchain automates monitoring, reporting, and verification (MRV), streamlining payments and enhancing governance in sustainable investments (Hartmann and Thomas 2020). Greater transparency also promotes equity by reducing incumbents' informational advantage. However, FinTech's impact on financial transparency depends on market and product design. Without reforming the underlying logic of information mechanisms, FinTech can perpetuate the performativity and depoliticisation of disclosure, legitimising environmental harm rather than mitigating it (Bracking 2012, 2015, 2019). Similarly, automating sustainability reporting often could perpetuate 'audit culture' and its power imbalances in sustainability governance (Bernards et al. 2020, 2024), with little effect on corporate behavior or investment decisions (Christophers 2017; Liu et al. 2019).

In addition to these four FinTech promises and their counters, emergent research has raised alarms over the negative environmental impact of maintaining the growing digital economy and various FinTech applications, owing to the energy-, carbon-, and water-intensive underlying data centre infrastructure (Chow et al. 2023; Jones 2018). In short, FinTech is no panacea for governance issues or finance's negative environmental and social impacts (Bateman et al. 2019), as recent scandals highlight (Engelen 2021; Scheer 2023). While its four 'promises' are enticing, their realisation depends on strong governance and appropriate market design (See Table 1). This underscores the need to scrutinise its actual impact in specific contexts, including the distribution of FFF platforms and funds, and to compare its role with traditional finance—aligning with our two research objectives.

[INSERT TABLE 1 HERE]

## 3. Methods

Inductive and interpretivist approaches were taken to build an analytical understanding of the first FinTech platforms integrating tree planting into their business models, branding, and operating costs. Such approaches are deemed appropriate when few prior studies have been conducted on a nascent topic (Schreier et al., 2012). The units of analysis are the FinTech platforms themselves, the project sites where trees are planted, and project developers and implementers in the tree planting sector with whom FinTechs partner to action tree planting.

To be included, a FFF had to have one or more platforms/products dedicated to raising capital to fund tree planting. We have exclusively examined FinTechs that are currently engaged in tree planting initiatives and have excluded the more recently emerged FinTechs that are still undergoing processes of fund-raising or project development with no tangible tree planting outcomes yet. This includes FinTechs with a broad portfolio of products where the tree-oriented product is only one of many, as well as FinTechs that are dedicated solely to raising or facilitating investment towards tree planting. These inclusion criteria allow us to stocktake the variety of business and investment models of FFF. However, we exclude FinTechs that contribute to tree planting initiatives on an ad-hoc or one-off basis because we believe these projects lack scale, scope, and longevity, falling short of integrating tree planting into core business operations.

We sourced a comprehensive array of texts and media. These included FinTech webpages, reports, financial reports, press releases, newsletters, secondary interviews, and video presentations - pertaining to both the FinTechs and their tree planting endeavours. These sources were identified via internet searches, manually read, and undertook content analysis - the systematic in-depth analysis of text (Holsti, 1969). Our content analysis was performed deductively. Deductive analysis involves using empirical data to test existing theories and frameworks. As such, data were identified, extracted, and organised according to the four key promises of green FinTech explained in Section 2 and serving as our analytical framework: (1) amount of financing (2) inclusivity (3) democratisation, and (4) transparency. This approach yielded the data appropriate for addressing Research Objective 2, and the diversity of material ensured that information reported by different sources and actors could be triangulated effectively. Alongside this, we also extracted key specifics related to each FinTech's (i) tree planting and fundraising goals, existing progress, planting activities, location, and tree species planted, (ii) institutional and community partners, and (iii) intended outcome and impact. Since different FinTechs monitor and report their activities differently, we also made note of the level of detail of reporting, and indeed when information was not available. This extraction of key specifics yielded the data appropriate for addressing Research Objective 1.

These methods enable us to fulfil our aim to investigate how FinTech impacts the effective and equitable scaling of forestation via tree planting, and are currently appropriate and useful given that FFF remains an emergent research phenomenon. Nevertheless, as knowledge on FFF is compiled, and as insights and inferences are drawn, we advocate future studies that employ primary qualitative and quantitative data collection, such as interviews with actors in the sector, ecological assessments, and case studies of afforestation programmes, to build on our study.

## 4. Results & Discussion

### 4.1 The spatiality of FinTech for forests

We examined eight FFF platforms (see Figure 1) that have dedicated part or all of their operations to tree planting, in addition to the Mastercard Priceless Planet Coalition (PPC), which has enabled the rapid spread of FFF by providing the application programming interfaces (APIs) necessary for other firms to adopt and provide tree-planting products. These platforms seek to appeal directly to retail consumers or to consumer-facing businesses with a value proposition of syphoning a proportion of their everyday spending into tree planting initiatives, thus providing consumers with a straightforward means of greening their everyday consumption habits. Our analysis shows that FFF is a globalising agenda encompassing every continent, but the majority of FFF platforms are headquartered in the developed world (Figure 1). They typically invest in tree planting in their home country (Aspiration, Mogo, Tred) and/or developing countries (Aspiration, Bung, Flowe, Mogo, Tred, TreeCard); none planted trees in other developed countries. This uni-directional flow of capital aligns with existing research explaining patterns of global north-south flows of donations for social and environmental sustainability purposes (Adelman 2009). Developing world destinations are the dominant location of tree planting initiatives, partly because the material and labour costs of planting a tree are significantly higher in developed countries (Holl and Brancalion, 2022). The mirrors existing patterns of forest financing, which risks perpetuating economic and environmental power imbalance between 'developed' and developing countries, where the former dictates environmental outcomes and futures of the latter (Neumann 2004).

Of the two platforms headquartered in the developing world (Ant Forest and GForest), both are subsidiaries of mobile money giants in their domestic jurisdictions (namely Ant Finance and GCash) and plant trees exclusively in their home countries. Traversing this group of dedicated FFF platforms is Mastercard PPC which, although headquartered in the USA - where Mastercard PPC's implementation partners Conservation International and the World Resources Institute are all headquartered - accrues finance via the FinTech applications of over 57 financial institutions, 37 FinTechs, and 45 non-financial corporate partners across the developed (n=114) and developing countries (n=26)<sup>2</sup>. Tree planting from Mastercard PPC takes place in 18 countries that do not necessarily align with the home countries of the 140 coalition members, and include both developed (6) and developing (12) countries. The involvement of Ant Forest, GForest, and Mastercard demonstrates the interest from FinTech and consumer financial services incumbents in FFF.

#### [INSERT FIGURE 1 HERE]

The location of FFF platforms' headquarters determines the geographies of retail consumers who have access to tree planting via FFF as national regulatory frameworks typically restrict consumers to banking within specific jurisdictions. Tred, for example, is an online financial

<sup>&</sup>lt;sup>2</sup> We acknowledge the differentiation between 'developing' and 'developed' countries is contentious and at times arbitrary. For the purpose of this paper, we have followed the UNFCCC's differentiation between developing and developed nations. However, we note that many highly developed economies, such as Hong Kong (n=3), Singapore (n=4), and Taiwan (n=5) are classified as 'developing' under the UNFCCC. Discounting these economies, we will see an even thinner participation from developing economies.

management platform tailored for businesses that can only accept consumers located within the UK, where it is based. The typically entrepreneurial nature of FFF platforms means that they generally start small as start-ups, scaling up over time, which may enable their expansion into new markets. Bung, for example, is a neobank which currently only accepts consumers within the EU. However, they have recently applied for a US banking licence, which would enable US consumers to open bank accounts with them. Furthermore, because of their need to launch quickly, many of these platforms are not banks as per regulatory definitions. Instead, they are digital payment services or financial management platforms, which partner with existing banks to enable their customers to have banking services without the need for an expensive banking licence. This may have the positive side effect of enabling a wider array of users to participate. GForest, for example, accepts users from all over the world because its owner firm, GCash, is not registered as a bank. Rather, GCash (which owns GForest) transfers its clients' cash deposits into 'e-money' to bypass Filipino regulatory restrictions, and in turn, its clients are not protected by the Philippines Deposit Insurance Corporation in the event of default. Consequently, the consumer base for FFF is potentially global, albeit restricted and shaped by various regulatory jurisdictional issues and the particularities of the FinTechs involved.

None of the FFF platforms we examined have any planting capacities themselves. Rather, they outsource management of planting responsibilities to project developers such as Eden Reforestation Projects, One Tree Planted, and Veritree who specialise in managing relationships with planting organisations from around the world. In some limited cases such as AntForest and GForest, the tree-planting is outsourced directly to local NGOs or philanthropic foundations who are responsible for planting as project implementers (Loizeaux, 2023). The types of relationships between FFF and project developers can differ. Aspiration, for instance, has used several project developers (Eden Reforestation Projects and Veritree), while Bung and Mogo rely solely on Eden Reforestation Projects. The use of project developers in the tree planting sector is common given the complex multifaceted decisionmaking processes that go into successful tree planting projects (Brancalion and Holl, 2020; Mansourian and Vallauri 2023). Figure 2 illustrates the typical actors involved in FFF and their interconnections. Compared to the configuration of actors typically found in tree planting initiatives by multinational corporations (Mansourian and Vallauri 2023), the unique addition of FFF lies in their reach to both retail and institutional clients. Moreover, some FFFs have collaborated with intermediaries (e.g. Veritree) who deploy digital solutions such as blockchain to monitor, report, and verify on tree-planting progress.

[INSERT FIGURE 2 HERE]

Similarly, these project developers do not do any planting themselves and instead rely on the capabilities of planters acting as project implementers. These planters are typically incumbent actors in the forestation sector, such as environmental NGOs, professional tree-planting companies, and government forestry departments (Mansourian and Vallauri 2023). Some project developers may financially incentivise local planters to participate in planting trees (Ewane, 2023; Tedesco et al., 2023). Such incentives, along with other funds to cover the costs of tree planting (e.g., seedling and sapling procurement), are typically provided in tranches, conditional on performance against ecological and social indicators – such that project developers are likely to only continue partnering with, and supporting, planters with positive track records. From our analysis, FFFs have typically worked with a pool of international project developers that are preferred by multinational corporations looking to conduct tree planting activities (Mansourian and Vallauri 2023). Hence, the geography of FFF

is mirrored and underpinned by these project developers working as intermediaries which - akin to most of the FFFs - are typically based in developed countries, but which partner with planters in developing countries (Holl and Brancalion 2022).

Lastly, several agents act as verifiers, tasked with measuring, recording, and publishing data on the success of the tree planting initiatives. Some of these agents, such as Veritree, can serve as both intermediaries between FinTechs and planters, and verifiers given the MRV technology that they use. Other verifiers, such as Verra, have devised bespoke monitoring and verification methodologies such as 'VM0047 Afforestation, Reforestation, and Revegetation' (Verra, 2023).

Mapping the distribution of FFF actors indicates challenges regarding inclusion of new FinTech users and planters, as well as information transparency issues commonly found in the forestation sector. We will elaborate in greater depth in subsequent sections the extent to which FFF has fulfilled the four 'promises' of green FinTech.

### **4.2** Scrutinising green FinTech's application to tree planting

Having established the spatial distribution of the FFF value chain, this section scrutinises whether FFF achieves its purported benefits as discussed in Section 2 and Table 1, thus addressing Objective 2.

#### 4.2.1 Amount of financing

FFFs have been effective in opening up novel avenues for individuals and businesses to participate in payment or donation initiatives to channel capital towards tree planting. As Table 2 shows, all nine of these largest and most established FFFs have made divergent fund-raising and tree planting commitments, albeit with different levels of transparency of targets and delivery timelines. A unique value of FFF is reaching a user base of retail consumers and small businesses that otherwise would have no means to be involved in financing tree planting at the same scale. This is further complemented by attractive or even gamified user interfaces to attract and retain consumers who otherwise may have lost interest in the process of funding tree planting through more mundane donation mechanisms.

However, it is unclear how 'users engaged' and 'trees planted' translates directly into financial flows. It is notable that the FinTechs analysed only disclose the number of trees planted as a result of their financial contributions, rather than the value of those financial contributions themselves. As such, it was not possible for us to accurately stocktake the extent to which FFF has enhanced financial flows towards forestation or critically assess whether financial resources were distributed efficiently across the FFF value chain, Nevertheless, even if the most conservative 'cost per tree' values of \$0.10 per tree (reportedly used by Eden Forestation Projects) or \$1 per tree (reportedly used by The Canopy Project) were used, this would mean most FinTechs would have contributed hundreds of thousands, or millions, of US dollars to this endeavour, respectively. Based on the reported number of trees planted in the cases of Aspiration (25m) and Ant Forest (>450m), this financial contribution could potentially be in the tens of millions of dollars. However, as depicted in the rightmost column of Table 2, there is significant variety between FFFs when it comes to the specifics of business models and particularly on what consumers must do for a tree to be planted. Consequently, it is hard to say concretely and consistently how FFFs have contributed to reducing climate funding gaps. We noted, however, this very lack of transparency is worthy of critical analysis (see Section 4.2.4).

Yet, it is clear that FFF offers platforms that hold the potential to engage significant numbers of individual consumers such that tree planting projects can be funded with relative ease. Most FFFs have been established in the last five years so it would be premature to definitively comment on their longevity. That being said, their business models are structured to be long-term and self-sustaining, contrasting with the transient nature of one-off corporate social responsibility endeavours, philanthropic contributions, or reliance on government grants which have dominated the financing of tree planting for decades (Löfqvist et al., 2023; Tedesco et al., 2023; Thompson, 2018; 2019; UNEP, 2021). Indeed, multiple FFFs examined claim to be currently oversubscribed (e.g. Treecard) or have expansion plans (e.g. Bunq, Tred), suggesting a healthy growth in interest and demand for such products from consumers and businesses.

Although there was a blank slate to develop innovative mechanisms for raising capital for forestation, we found a limited variety and innovation of capital-raising models. The most common modality of raising investment for tree planting is for either the consumer or their payment service provider to dedicate a proportion of their revenue or profits towards tree planting initiatives, with additional options for consumer and corporate donation (see also the leftmost column of Table 3 for a summary). Interestingly, FFFs have not tapped into crowdfunding or peer-to-peer financing commonly found in other FinTech platforms.

Furthermore, of the FFFs examined, only Aspiration has used their tree planting initiatives to generate forest carbon credits for trade on either international or domestic voluntary carbon markets. It could be possible for other FFFs to do the same given that some of the major intermediaries have established associated forest carbon enterprises; for example, Compassionate Carbon is a subsidiary of Eden Reforestation Projects. Relatedly, it has also been postulated that Ant Forest's owner, AntGroup, could consider selling forest carbon credits from its tree planting sites in the future (Loizeaux, 2023). Currently, however, tree planting through FFFs is done primarily or exclusively for ecological restoration, which could limit the liquidity of these initiatives, thereby hindering the full potential of FFF in generating and channelling new sources of capital to nature-based solutions to climate change.

[INSERT TABLE 2 HERE]

#### 4.2.2 Inclusivity

Similar to how FinTech in general has made financial services more accessible (Langley and Leyshon 2022), FFF has made contributing financially to tree planting initiatives accessible to everyday consumers. Through the use of digital apps and bank cards, individuals can participate passively through engaging in regular day-to-day purchases and payments (e.g. by using a 'green' bank card, tracking 'green activities' undertaken per day, rounding up purchases). This provides a means for individuals to engage with tree planting in a way that was previously unavailable - intentionally yet passively and continuously. Importantly, this method of engagement means that the barriers to entry for potential consumers are almost zero. Furthermore, initiatives such as Mastercard PPC streamline the process for enterprises and corporations - who otherwise lack the resources, networks, or technical expertise - to commit part of their revenue to tree planting. In that sense, FFF increases inclusivity by lowering the entry barrier to a broader array of actors to contribute to forest financing.

However, as mentioned in Section 4.1, participation in FFF by everyday consumers is restricted by headquarter location of FFFs, which is determined by regulatory configurations as well as the clustering tendency of entrepreneurs, investors, and perceived consumer interest in particular geographies (Harris, 2021; Laidroo and Avarmaa 2020). As we have seen, that has created a geographical bias towards developed countries, although consumers

in many developed countries remain without a FFF option to utilise. Indeed, even though Mastercard PPC operates globally, our analysis reveals that the majority of its partners are from developed countries. Therefore, FFF is disproportionately inclusive to users located in developed countries, despite Ant Forest and GForest demonstrating that FFF is a model that has the potential to work globally. Thus, the potential of FFF to drive inclusivity is limited by existing regulatory and financial network configurations, and the extent to which it has been forest investment more accessible is highly fragmented.

More importantly, FFFs have fallen short on delivering enhanced inclusivity for a broader range of planters and forest communities. As mentioned in Section 4.1, FFF has followed the status quo of the traditional forestation sector to outsource planting activities to developers who are in turn connected to their trusted local planters. To this end, newer, smaller-scale, and/or, emergent planters have not benefited from green FinTech's promise of enhancing financial inclusivity.

#### 4.2.3 Democratisation

Despite broadening forest financing to a wider variety of consumers, finance accruing through FFF engagement is typically pooled and overseen by the FFF itself, with no input from their users as to where the resource would be dedicated, barring two exceptions (Ant Forest and GForest). This is especially the case for Mastercard PPC where the end users are two-steps removed from the decision-making process taking place centrally within Mastercard. In such cases, the use of FinTech does not make the process of financing tree planting any more 'democratic' for users to determine where tree-planting takes place, species of trees planted, and how the restored forests or ecosystems are managed over time. More importantly, communities living in or relying on the forestation area have no opportunities to have their priorities and voices heard through participating in FFF. As mentioned earlier, FFF platforms continue to depend heavily on established project developers and implementers to carry out tree planting.

This delegation, or outsourcing, is the dominant trend within FFF. As illustrated in Figure 2, FinTechs outsource project management to various project developers, who in turn outsource to myriad project implementers. This is an industry norm (Mansourian and Vallauri, 2023) that enables FinTechs to streamline their business model in what is an exceptionally competitive financial services industry. However, it also undermines the potential for FFF to reform embedded configurations of tree planting and related investment where the decision-making and project execution power is concentrated in the hands often large-scale tree planting organisations and initiatives, and not devolving power to individual investors seeking to make change with their capital, let alone giving communities affected by tere planting a say. As such, it is not just the individual users but the FinTechs themselves that have limited control over the socio-material flows of finance for tree planting. Financial flows determining where, when, and how tree planting is performed are typically set by the pre-existing partnerships and networks established by the major project developers who embody the role of primary coordinators in the value chain.

By failing to leverage the potential of FinTech to efficiently channel investments directly to communities or smaller entities capable of undertaking smaller-scale plantation projects, the current configuration of FFF misses opportunities to equitably support new individuals (especially women) and communities to develop and participate in tree planting projects. By enabling direct transactions to individuals, FinTech can help prevent elite capture and corruption, and is particularly useful when planters are geographically dispersed across landscapes (Thompson, 2017). Yet, the reticence of FFFs to attempt this could reinforce the

unequal power dynamics between forestation communities and investors within the forestation value chain (Appiah and Gbeddy 2018; Ellias et al., 2022).

However, it should be noted that Ant Forest and GForest give their users some autonomy to decide where, when, or how their contributions will be spent on tree planting - providing an indication that more user-driven measures are something that FFFs could implement more broadly. Both apps seek to incentivise a greener lifestyle for their e-wallet users - Ant Group and GCash, respectively - by rewarding 'green energy points' to users who have made a 'green' consumption choices, for example by paying bills digitally or taking public transport, proportionate to the carbon emissions avoided by undertaking the 'green' activity (see Fig 3). These points can be collected and accumulated to plant a tree - either individually or collaboratively with another app user. The virtual planter is given a variety of native species to choose from. (Fig. 3). On Ant Forest, users are given an additional choice of *where* they want the tree to be planted and a simulated 'online patrol' to inspect the areas that they have contributed to reforesting (Ant Group 2023), whereas all virtual trees planted on GForest will be planted in locations selected by GCash.

The literature provides explanations for Ant Forest's pioneering role in creating an engaging, gamified model of forestation (Dal Maso 2022). Users can exercise their 'autonomy' only through engaging intensively with the Alipay platform (loyal usage of Alipay, daily collection of Green Energy points, ensuring friends are also using Alipay to unlock certain community gamified functions; see Fig. 3 for details), and their autonomy is limited to choosing from a pre-selected variety of species and locations. As a subsidiary of Alibaba, a Chinese company with partial state ownership, the gamified interface of AntForest co-opts individuals into the 'environmentality' of prescribed, quantified 'green' consumption behaviours (Dal Maso 2022). Indeed, Ant Forest's sustainability reports identify the government as a key stakeholder, and one way Ant Forest engages with the government is by participating in government-led projects. The Chinese government's 14th Five-Year Plan (2021-2025) aims to increase forest cover to 24.1% of the country's total land area. Additionally, China is actively combating desertification through initiatives like the 'Great Green Wall' project. Ant Forest's tree-planting activities on desert edges align closely with these national forestation priorities. This aligns with a broader trend in which tech and FinTech giants contribute to China's social and environmental authoritarian regime (Gruin 2019), using innovative FinTech avenues to advance state priorities (Loizeaux 2023). In contrast, GForest is not a state-owned company but instead is owned by Mynt, which is majority-owned by Ayala, one of the most economically and politically influential conglomerates in the Philippines. The adaptation of the Ant Forest model to GCash indicates the growing influence of a new FinTech-powered environmentality.

Thus, the furthest extent to which FFF has allowed retail investors and consumers to engage in forestation decision making is through Alipay and GCash's heavily prescriptive system. Other FFFs examined have not integrated user-led decision making in their platforms. Proponents of decentralised finance (DeFi) technologies argue that tokenisation on various distributed ledgers like Ethereum can enable consumer voting rights (Barbereau et al. 2023), which could offer consumers significantly more say in the types of projects that users plant trees in. Furthermore, we found no examples of FFF facilitating more two-way conversation between investors and planters to give greater say to forest communities over key issues such as fair remuneration and benefit-sharing. To this end, increased democratisation is therefore an area where FFFs are largely failing.

#### [INSERT FIGURE 3 HERE]

#### 4.2.4 Transparency

All FFFs examined are transparent about how consumer actions and spending translate into tree planting, although the information is presented differently, complicating the comparison between absolute value allocated to tree planting, the cost per tree planted, and the proportion of total revenue designated for tree planting (see also Table 3). For example, Bunq states on their website that a tree would be planted for every €100 spent using their Bunq cards, while Aspiration, Tred, and Treecard commit a proportion of their revenue to tree planting initiatives. Moreover, none of the FFFs examined have disclosed the allocation of financial resources to forestation activities.

Information transparency is even weaker with regards to where tree-planting takes place, what species are planted, and how they are managed. This goes against the grain of one key value proposition of green FinTech where technological innovations (such as blockchain) could be deployed to transparently evidence how each transaction can contribute to tree planting and forestation efforts (Kotsialou et al., 2022). Similar to how FFFs outsource planting activities, we found that some FFFs partner with external agents that utilise technological solutions to handle MRV of planting activity. For example, Veritree utilises blockchain to record that trees have been planted and are surviving (but such information is only available to its clients on the 'client hub'). Ecosia uses a combination of site visits and remote sensing to monitor species counts and density, while zeroCO2 takes a more gualitative approach to reporting progress in various project sites. However, it is at the discretion of the FFF to determine which partner they choose, the extent to which they take advantage of technological innovation to handle information, and how much information they share with their end users. Rather than streamlining information mechanisms, the linkage between consumer behaviour and material environmental outcomes is in fact two-steps removed owing to the opacity of how FFF companies typically deploy resources to tree planting initiatives and the divergence of reporting practices undertaken by external agents. Moreover, not all FFFs have used a verifier to trace the impact of their investments, and even fewer FFFs fully disclose to their users and investors verifier reports. This renders information availability to be fragmented and incomparable in the FFF space. To this end, FFF has perpetuated the informational opacity and inefficiencies found in green finance and in carbon markets that obfuscate the environmental impacts of investments (Bracking 2015; Newell and Bumpus 2012).

[INSERT TABLE 3 HERE]

### 4.3 Discussion

The FFF platforms examined each realised some of the four 'promises' of green FinTech. Moreover, while some of these promises are mutually synergistic, it is rare that FFF platforms realise all four promises. We will explain these phenomena in turn below and critically evaluate their implications for the extent to which FinTech can impact the effective and equitable scaling of forestation via tree planting - and ultimately, contribute to facilitating a sustainable market transformation.

We found that FFF can create new avenues for both business and retail users to participate in forestation donations and investments. To this end, FFF has also improved the inclusivity of who can participate and contribute towards forestation funding. While the majority of the FFFs analysed are based in developed countries, the two FFF platforms launched within developing countries have been able to leverage the sizable domestic consumer bases in China (Ant Forest) and the Philippines (GForest). To this end, increasing investment and enhancing user inclusivity seem to be mutually complementary (Figure 4). One of the value propositions of FFF companies is the prospect of empowering users with the information to make informed consumption decisions. By extension, a significant contribution of FFF lies in their innovative consumer education and incentive mechanisms (Bayram et al. 2022), which connects individual or enterprise consumption patterns with tree planting and carbon sequestration potential. Utilising interactive and gamified user interfaces (Lai and Langley, 2023), FFFs incorporate a 'nudge' for individuals and enterprises to reduce their carbon footprint through these financial and payment service platforms. By integrating donations into everyday payment systems, FFFs streamline the process of investing in tree planting. Thus, FFFs have attempted to establish a connection between users and their carbon footprint, offering users a solution to generate tangible environmental benefits through their digital platforms.

However, the four 'promises' of FFF are only selectively fulfilled, typically to the economic and/or reputational benefits of the FFF platform. The majority of FFFs are headquartered in developed economies, meaning consumers in developing countries (except those in China and the Philippines) have limited exposure to forestation activities. Importantly, FFF only improves forest finance inclusivity to end users and investors seeking to *contribute* funding to forestation projects, and does not extend to enterprises or communities *seeking financing* for their tree planting and maintenance work, thus excluding small holder farmers and land managers who often lack access to investments from traditional financial institutions (e.g. Starfinger, 2021). By engaging exclusively with well-established planting companies and their intermediaries, FFFs do not have to take on any potential risks of innovation failure. However, they are also missing a significant opportunity to develop or adopt technological solutions to engage a broader range of planters to expand the scope and variety of forestation initiatives.

Similarly, the extent to which FFF has improved forestation financing transparency is limited. While FFF platforms may seem to enhance transparency by allowing users to track their treeplanting contributions through everyday consumption—and in some cases, even follow their virtual tree's plantation via the app—it remains unclear how these platforms distribute the funds generated from user contributions. Transparency over the maintenance of forested areas, as well as any environmental and social co-benefits, is unclear. To this end, poor transparency also undermines the extent to which one can accurately assess the scale of FFF's financial contribution to the global agenda of forestation.

Democratisation is the weakest aspect of FFF. Among the platforms, only AntForest and GForest offer users limited choices of pre-approved species and locations. However, users, investors, and forestation communities have no real decision-making power over key factors such as species selection, resource distribution, distribution of benefits, or whether forestation should take place in a given location at all.

In short, FFF platforms have acknowledged FinTech's 'promises' but often fall short of fully implementing them in ways that challenge the existing structure of forestation financing. Expanding participation to a broader range of users and planters, while increasing investment and inclusivity, requires more advanced use of FinTech technologies to increase transparency and maintain connections between users and tree-planting activities. Similarly, achieving true democratisation requires well-designed and well-governed decision-making systems, which we have not observed widely in our analysis. While it is beyond the analytical bounds of this paper to deep dive into the environmental and social outcomes of each of these FFF platforms - and indeed a lot of these initiatives are too nascent for us to come to a conclusive verdict - the recent controversy surrounding Aspiration is an example of clever deployment of

marketing language to overblow its environmental achievements (Goldstein 2018; ProPublica 2021). Indeed, the information opacity observed across FFF could open up loopholes for corporate greenwashing.

FFF may present itself as an innovative approach to financing forestation, but in reality, it deepens neoliberal environmentality. The high concentration of FFF platforms in developed countries, coupled with their preference for financing forestation in less developed regions, reinforces existing Global North-South imbalances. By co-opting individual consumers and retail investors into the neoliberalisation of forestation, FFF shifts responsibility from institutions to individuals, pressuring them to adopt 'green' credit cards, engage in 'green' economic activities, and interact with FFF apps. At the same time, FFF has helped maintain the market dominance of large-scale tree-planting businesses by providing them with new revenue streams, despite persistent controversies over carbon accounting and the marginalisation of local communities. Early cases of greenwashing suggest that corporations, rather than aspiring local tree planters, or local communities co-located with forestation efforts, stand to gain the most from FFF—both financially and reputationally.

[INSERT FIGURE 4 HERE]

## 5. Conclusion

This paper responds to the recently emerged but rapidly evolving phenomenon of deploying FinTech to make finance more 'sustainable' in the face of contemporary climate and environmental crises. We focused on the rise of FFF, and mapped the distribution of headquarters, consumer base, and forestation locations. We then examined the extent to which FFF fulfils the 'promises' of green by increasing flows of sustainable investments, enhancing inclusivity, democratising finance, and improving transparency.

Our findings suggest that the main contribution of FFF lies in opening up the opportunity to invest, donate, and otherwise contribute to tree planting for everyday retail consumers and smaller scale enterprises that would otherwise not have the opportunity to participate in tree planting initiatives at scale. Furthermore, FFF is creating new configurations for tree planting investment by integrating everyday (green) consumption into models for generating capital to support planting initiatives. To this end, FFF may have contributed to raising public awareness in tree planting as a climate solution.

However, the extent to which FFF has fundamentally reformed forestation financing according to the four 'promises is limited. Practically, the reach of FFFs to both new investors and planters is constrained by incumbent financial regulatory frameworks and supply chain infrastructures. This is limiting the availability of FFF services to jurisdictions with a vibrant FinTech ecosystem, and tree planting activities to geographies with well-established planting organisations.

More importantly, rather than transforming forestation financing in a meaningful way, we found that FFF has reinforced existing structures that perpetuate neoliberal environmental logics. By integrating tree-planting into spending patterns, FFF appears to have made forestation financing more inclusive, but it has also devolved the responsibility of forestation on the individual while encouraging consumerism. Furthermore, it continues to scope sidelines smaller-scale planters, particularly those in developing economies, from accessing crucial

financial resources, further entrenching existing imbalances in global environmental finance and governance. Another key limitation of FFF lies in its failure to deliver on the promise of democratisation. This lack of participatory governance diminishes the potential of FinTech to function as a vehicle for equitable environmental decision-making. Instead, FFF platforms perpetuate a model in which financial flows and decision-making remain centralised in the hands of corporate actors. Finally, the landscape of disclosing and verifying tree planting outcomes and impact is highly uneven, suggesting that expanded MRV technological availability does not necessarily lead to adoption and enhancements in the transparency of tree planting investment chains. To this end, FFF has fallen short of fundamentally shifting power dynamics in decision-making or financial distribution.

We believe FFFs should deploy technological solutions to include a broader range of smallerscale planters in a greater diversity of locations, and adopt user interfaces that allow greater democratic choice for everyday consumers to engage in the investment and decision-making of tree planting. Falling short of that, we caution that the 'FinTech' in FFF could be viewed as a marketing veil masking 'business-as-usual' forestation financing that is plagued by opaque accountability mechanisms and an unequal distribution of socio-environmental benefits (Kirschbaum et al. 2024). This article has revealed the current landscape of FFF and highlighted key opportunities and challenges for FinTech innovations to help scale tree planting. When FFFs become more mature amongst retail users, corporate sector, and the tree-planting sector, future research could deploy a combination of quantitative and qualitative methodology to measure the environmental and social outcomes of FFF. This can include remote-sensing and/or ground-truthing of the tree planting locations to investigate their carbon sequestration, biodiversity conservation, and/or community up-lift potential. Qualitative methodologies such as as semi-structured interviews or ethnography can be deployed to compare and scrutinise the motivations, capacities, and experiences of financial and corporate actors versus everyday users and tree-planting organisations and communities participating in FFF, building on previous work that has done so for a broader suite of financial actors engaged in forest restoration (c.f. Löfqvist et al. 2023). This is imperative to unearth the environmental-social-financial tradeoffs that FFF must navigate, identify how FFF can retain and attract investors and consumers to become an integral component to forest restoration financing, and devise appropriate measures to ensure the integrity of FFF as the market continues to evolve.

Disclosure of Interest Statement: The authors have no conflict of financial or non-financial interest to declare.

Data Availability Statement: The data that support the findings of this study are available in corporate reports, websites, and the media. The data that support the findings of this study are available on request from the corresponding author, FHML.

Funding Statement: No funding was received.

Acknowledgments: BST acknowledges his DECRA fellowship (DE240100092) awarded by the Australian Research Council (ARC).

## References

Adelman, C. (2009). Global philanthropy and remittances: Reinventing foreign aid. *The Brown Journal of World Affairs*, *15*(2), 23–33.

Anagnostopoulos, I. (2018). Fintech and regtech: Impact on regulators and banks. *Journal of Economics and Business, 100*, 7–25. DOI:10.1016/j.jeconbus.2018.07.003

Appiah, D. O., & Gbeddy, S. E. (2018). A synthesis of the implementation ambivalence of REDD+ in Sub-Saharan Africa and Southeast Asia. *Forest and Society, 2*(1), 92–111. DOI: 10.24259/fs.v2i1.2918

Arner, D. W., Barberis, J., & Buckey, R. P. (2016). FinTech, RegTech, and the reconceptualization of financial regulation. *Northwestern Journal of International Law & Business*, *37*(3), 371.

Austin, K. G., Baker, J. S., Sohngen, B. L., Wade, C. M., Daigneault, A., Ohrel, S. B., ... & Bean, A. (2020). The economic costs of planting, preserving, and managing the world's forests to mitigate climate change. *Nature Communications, 11*(1), 5946. DOI: 10.1038/s41467-020-19578-z

Awais, M., Afzal, A., Firdousi, S., & Hasnaoui, A. (2023). Is fintech the new path to sustainable resource utilisation and economic development? *Resources Policy, 81*, 103309. DOI: 10.1016/j.resourpol.2023.103309

Baird, I. G., & Green, W. N. (2020). The Clean Development Mechanism and large dam development: Contradictions associated with climate financing in Cambodia. *Climatic Change*, *161*(2), 365–383. DOI: 10.1007/s10584-019-02621-4

Barbereau, T., Smethurst, R., Papageorgiou, O., Sedlmeir, J., & Fridgen, G. (2023). Decentralised Finance's timocratic governance: The distribution and exercise of tokenised voting rights. *Technology in Society*, *73*, 102251. DOI: 10.1016/j.techsoc.2023.102251

Bateman, M., Duvendack, M., & Loubere, N. (2019). Is fin-tech the new panacea for poverty alleviation and local development? Contesting Suri and Jack's M-Pesa findings published in *Science. Review of African Political Economy, 46*(161), 480–495. DOI: 10.1080/03056244.2019.1614552

Bateman, M., & Maclean, K. (2017). *Seduced and betrayed: Explaining the contemporary microfinance phenomenon*. University of New Mexico Press.

Bayram, O., Talay, I., & Feridun, M. (2022). Can FinTech promote sustainable finance? Policy lessons from the case of Turkey. *Sustainability, 14*(19), 12414. DOI: **10.3390/su141912414** 

Bernards, N. (2019). Tracing mutations of neoliberal development governance: 'Fintech', failure and the politics of marketization. *Environment and Planning A: Economy and Space, 51*(7), 1442–1459. DOI: 10.1177/0308518X19862576

Bernards, N. (2022). Colonial financial infrastructures and Kenya's uneven fintech boom. *Antipode, 54*(3), 708–728. DOI: 10.1111/anti.12810

Bernards, N., Campbell-Verduyn, M., & Rodima-Taylor, D. (2024). The veil of transparency: Blockchain and sustainability governance in global supply chains. *Environment and Planning C: Politics and Space, 42*(5), 742–760. DOI:10.1177/23996544221142763

Bernards, N., Campbell-Verduyn, M., Rodima-Taylor, D., Duberry, J., DuPont, Q., Dimmelmeier, A., ... & Reinsberg, B. (2020). Interrogating technology-led experiments in sustainability governance. *Global Policy*, *11*(4), 523–531. DOI: 10.1111/1758-5899.12826.

Bracking, S. (2012). How do investors value environmental harm/care? Private equity funds, development finance institutions and the partial financialization of nature-based industries. *Development and Change, 43*(1), 271–293. DOI: 10.1111/j.1467-7660.2011.01756.x

Bracking, S. (2015). The anti-politics of climate finance: The creation and performativity of the green climate fund. *Antipode*, *47*(2), 281–302. DOI: 10.1111/anti.12123

Bracking, S. (2019). Financialisation, climate finance, and the calculative challenges of managing environmental change. *Antipode*, *51*(3), 709–729. DOI: 10.1111/anti.12510

Brancalion, P. H. S., Meli, P., Tymus, J. R. C., Lenti, F. E. B., Benini, R. M., Silva, A. P. M., ... & Holl, K. D. (2019). What makes ecosystem restoration expensive? A systematic cost assessment of projects in Brazil. *Biological Conservation, 240*, 108274. DOI: 10.1016/j.biocon.2019.108274

Brancalion, P. H. S., & Holl, K. D. (2020). Guidance for successful tree planting initiatives. *Journal of Applied Ecology*, *57*(12), 2349–2361. DOI:10.1111/1365-2664.13725

Brockhaus, M., Di Gregorio, M., Djoudi, H., Moeliono, M., Pham, T. T., & Wong, G. Y. (2021). The forest frontier in the Global South: Climate change policies and the promise of development and equity. *Ambio, 50*, 2238–2255. DOI: /10.1007/s13280-021-01602-1

Bryant, G., & Webber, S. (2024). *Climate finance: Taking a position on climate futures*. Newcastle upon Tyne: Agenda Publishing.

Buchak, G., Matvos, G., Piskorski, T., & Seru, A. (2018). Fintech, regulatory arbitrage, and the rise of shadow banks. *Journal of Financial Economics, 130*(3), 453–483. DOI: 10.1016/j.jfineco.2018.03.011

Butticè, V., & Vismara, S. (2022). Inclusive digital finance: The industry of equity crowdfunding. *The Journal of Technology Transfer, 47*(4), 1224–1241. DOI:10.1007/s10961-021-09875-0

Cai, C. W. (2018). Disruption of financial intermediation by FinTech: A review on crowdfunding and blockchain. *Accounting & Finance, 58*(4), 965–992. DOI: 10.1111/acfi.12286

Carter, S., Manceur, A. M., Seppelt, R., Hermans-Neumann, K., Herold, M., & Verchot, L. (2017). Large scale land acquisitions and REDD+: A synthesis of conflicts and opportunities. *Environmental Research Letters*, *12*(3), 035010. DOI 10.1088/1748-9326/aa6056

Cao, S., Wang, G., & Chen, L. (2010). Questionable value of planting thirsty trees in dry regions. *Nature, 465*(7294), 31–31. DOI: 10.1038/465031d

Caviola, L., Schubert, S., & Greene, J. D. (2021). The psychology of (in)effective altruism. *Trends in Cognitive Sciences*, *25*(7), 596–607. DOI: 10.1016/j.tics.2021.03.015

Chomba, S., Kariuki, J., Lund, J. F., & Sinclair, F. (2016). Roots of inequity: How the implementation of REDD+ reinforces past injustices. *Land Use Policy*, *50*, 202–213. DOI:10.1016/j.landusepol.2015.09.021

Chow, W., Lai, K., & Liu, F. (2023). *Interim Report: Green FinTech and Data Centres in Singapore*. Available at <u>https://www.singaporegreenfinance.com/research/interim-report-green-fintech-and-date-centres-in-singapore/</u> (Accessed on 30th April 2023)

Christophers, B. (2017). Climate change and financial instability: Risk disclosure and the problematics of neoliberal governance. *Annals of the American Association of Geographers, 107*(5), 1108–1127. DOI: 10.1080/24694452.2017.1293502

Cohen, D., Nelson, S., & Rosenman, E. (2022). Reparative accumulation? Financial risk and investment across socio-environmental crises. *Environment and Planning E: Nature and Space*. DOI: 10.1177/25148486211030432

Coleman, E. A., Schultz, B., Ramprasad, V., Fischer, H., Rana, P., Filippi, A. M., ... & Fleischman, F. (2021). Limited effects of tree planting on forest canopy cover and rural livelihoods in Northern India. *Nature Sustainability, 4*(11), 997–1004. DOI:10.1038/s41893-021-00761-z

Cumming, D., Meoli, M., & Vismara, S. (2021). Does equity crowdfunding democratize entrepreneurial finance? *Small Business Economics*, *56*(2), 533–552. DOI: 10.1007/s11187-019-00188-z

D'Orazio, P., Scholtens, B., de Mariz, F., González-Ruiz, J. D., Ullah, S., Adegbite, O., ... & Berg, M. (2023). Catalyzing the transformation to sustainable finance. *One Earth*, *6*(10), 1271–1276. DOI: 10.1016/j.oneear.2023.09.011

DAI Magister. (2023). *Climate FinTech: The key to unlocking wider climate tech solutions*. Available at: <u>https://www.daimagister.com/resources/climate-fintech/</u> (Accessed on 30th April 2023)

Dal Maso, G. (2022). The Promethean ant forest: Alibaba's app as a financialising environmental tool. *Made in China Journal,* 7(2), 144–149.

Dawson, N. M., Mason, M., Mwayafu, D. M., Dhungana, H., Satyal, P., Fisher, J. A., ... & Schroeder, H. (2018). Barriers to equity in REDD+: Deficiencies in national interpretation processes constrain adaptation to context. *Environmental Science & Policy, 88*, 1–9. DOI: j.envsci.2018.06.009

Dempsey, J. (2016). *Enterprising nature: Economics, markets, and finance in global biodiversity politics*. John Wiley & Sons.

Díaz, A., Esparcia, C., & Huélamo, D. (2023). Unveiling the diversification capabilities of carbon markets in NFT portfolios. *Finance Research Letters, 58*, 104632. DOI: 10.1016/j.frl.2023.104632

Di Sacco, A., Hardwick, K. A., Blakesley, D., Brancalion, P. H., Breman, E., Cecilio Rebola, L., ... & Antonelli, A. (2021). Ten golden rules for reforestation to optimize carbon sequestration, biodiversity recovery and livelihood benefits. *Global Change Biology, 27*(7), 1328–1348. DOI: 10.1111/gcb.15498

Dixon, R., & Challies, E. (2015). Making REDD+ pay: Shifting rationales and tactics of private finance and the governance of avoided deforestation in Indonesia. *Asia Pacific Viewpoint*, *56*(1), 6–20. DOI: 10.1111/apv.12085

Duchelle, A. E., Simonet, G., Sunderlin, W. D., & Wunder, S. (2018). What is REDD+ achieving on the ground? *Current Opinion in Environmental Sustainability*, *32*, 134–140. DOI: 10.1016/j.cosust.2018.07.001

Elias, F., Ferreira, J., Resende, A. F., Berenguer, E., França, F., Smith, C. C., ... & Barlow, J. (2022). Comparing contemporary and lifetime rates of carbon accumulation from secondary forests in the eastern Amazon. *Forest Ecology and Management, 508*, 120053. DOI: 10.1016/j.foreco.2022.120053

Engelen, K. C. (2021). Germany's Wirecard scandal. *The International Economy*, *35*(1), 9–12. DOI: 10.1108/JFC-12-2022-0301

European Merchant Bank. (2023). *The rise of sustainable fintech: Bridging the gap between finance and environmental responsibility*. Available at: <u>https://em.bank/blog/fintech/the-rise-of-sustainable-fintech-bridging-the-gap-between-finance-and-environmental-responsibility/</u> (Accessed on 30th April 2023)

Evans, M. C. (2018). Effective incentives for reforestation: Lessons from Australia's carbon farming policies. *Current Opinion in Environmental Sustainability*, *32*, 38–45. DOI: j.cosust.2018.04.002

Ewane, E. B. (2024). Understanding community participation in tree planting and management in deforested areas in Cameroon's Western Highlands. *Environmental Management*, *73*(1), 274–291. DOI: 10.1007/s00267-023-01902-0

Fagan, M. E., Reid, J. L., Holland, M. B., Drew, J. G., & Zahawi, R. A. (2020). How feasible are global forest restoration commitments? *Conservation Letters, 13*(3). DOI: 10.1111/conl.12700

Fleischman, F., Basant, S., Chhatre, A., Coleman, E. A., Fischer, H. W., Gupta, D., ... & Veldman, J. W. (2021). Pitfalls of tree planting show why we need people-centered natural climate solutions. *BioScience*, *70*(11), 947–950. DOI: 10.1093/biosci/biaa094

FlowCarbon. (2023). *The role of digital environmental assets in Article 6 and beyond*. Available at: <u>https://www.flowcarbon.com/knowcarbon/the-role-of-digital-environmental-assets-in-article-6-and-beyond</u> (Accessed on 30th April 2023)

Gabor, D. (2021). The Wall Street consensus. *Development and Change, 52*(3), 429–459. DOI: 10.1111/dech.12645

GCash. (2024). *How can I plant a tree in GForest*. Available at: <u>https://help.gcash.com/hc/en-us/articles/360025619494-How-can-I-plant-a-tree-in-GForest</u> (Accessed on 21st February 2025)

Goldstein, J. (2018). *Planetary improvement: Cleantech entrepreneurship and the contradictions of green capitalism*. MIT Press.

Grand View Research. (2022). Crowdfunding market size, share & trends analysis report by type (equity-based, debt-based), by application (food & beverage, technology, media, healthcare, real estate), by region, and segment forecasts, 2023–2030. Available at: <a href="https://www.grandviewresearch.com/industry-analysis/crowdfunding-market-report">https://www.grandviewresearch.com/industry-analysis/crowdfunding-market-report</a> (Accessed on 30th April 2024)

Gruin, J. (2019). Financializing authoritarian capitalism: Chinese fintech and the institutional foundations of algorithmic governance. *Finance and Society*, *5*(2), 84–104. DOI: 10.2218/finsoc.v5i2.4135

Harasheh, M., Bouteska, A., & Manita, R. (2024). Investors' preferences for sustainable investments: Evidence from the US using an experimental approach. *Economics Letters, 234*, 111428. DOI:10.1016/j.econlet.2023.111428

Harris, J. L. (2021). Bridging the gap between 'Fin' and 'Tech': The role of accelerator networks in emerging FinTech entrepreneurial ecosystems. *Geoforum, 122*, 174–182. DOI:10.1016/j.geoforum.2021.04.010

Hartmann, S., & Thomas, S. (2020). Applying blockchain to the Australian carbon market. *Economic Papers: A Journal of Applied Economics and Policy, 39*(2), 133–151. DOI: 10.1111/1759-3441.12266

Holl, K. D., & Brancalion, P. H. S. (2022). Which of the plethora of tree-growing projects to support? *One Earth, 5*(5), 452–455. DOI: 10.1016/j.oneear.2022.04.001

Holsti, O. R. (1969). *Content analysis for the social sciences and humanities*. Addison-Wesley.

Howson, P. (2019). Tackling climate change with blockchain. *Nature Climate Change*, 9(9), 644–646. DOI: 10.1038/s41558-019-0567-9

Hua, W., Jiang, J., Sun, H., & Wu, J. (2020). A blockchain-based peer-to-peer trading framework integrating energy and carbon markets. *Applied Energy*, *279*, 115539. DOI: 10.1016/j.apenergy.2020.115539

Ingalls, M. L., Meyfroidt, P., To, P. X., Kenney-Lazar, M., & Epprecht, M. (2018). The transboundary displacement of deforestation under REDD+: Problematic intersections between the trade of forest-risk commodities and land grabbing in the Mekong region. *Global Environmental Change*, *50*, 255–267. DOI: 10.1016/j.gloenvcha.2018.04.003

International Capital Market Association. (2020). *Sustainable finance high-level definitions*. Available at: <u>https://www.icmagroup.org/assets/documents/Regulatory/Green-</u> <u>Bonds/Sustainable-Finance-High-Level-Definitions-May-2020-051020.pdf</u> (Accessed on 21st February 2025)

Ioannou, S., & Wójcik, D. (2022). The limits to FinTech unveiled by the financial geography of Latin America. *Geoforum, 128*, 57–67. DOI: 10.1016/j.geoforum.2021.11.020

Jones, N. (2018). How to stop data centres from gobbling up the world's electricity. *Nature*, *561*(7722), 163–166. DOI: *10.1038/d41586-018-06610-y* 

Kaal, W. A. (2016). Dynamic regulation for innovation. In M. Fenwick, W. A. Kaal, T. Kono, & E. P. M. Vermeulen (Eds.), *Perspectives in law, business & innovation* (pp. 16–22). Springer.

Kim, T. W., & Werbach, K. (2016). More than just a game: Ethical issues in gamification. *Ethics and Information Technology, 18*(2), 157–173. DOI: 10.1007/s10676-016-9401-5

Kirschbaum, M. U., Cowie, A. L., Peñuelas, J., Smith, P., Conant, R. T., Sage, R. F., ... & Robinson, S. A. (2024). Is tree planting an effective strategy for climate change mitigation? *Science of the Total Environment, 909*, 168479. DOI: 10.1016/j.scitotenv.2023.168479

Kotsialou, G., Kuralbayeva, K., & Laing, T. (2022). Blockchain's potential in forest offsets, the voluntary carbon markets and REDD+. *Environmental Conservation, 49*(3), 137–145. DOI: 10.1017/S0376892922000157

Kovacic, Z., García Casañas, C., Argüelles, L., Yáñez Serrano, P., Ribera-Fumaz, R., Prause, L., & March, H. (2024). The twin green and digital transition: High-level policy or science fiction? *Environment and Planning E: Nature and Space*, *7*(6), 2251–2278. DOI: 10.1177/25148486241258046

KPMG. (2015). *FinTech 100: Leading global innovators report 2015*. Available at: <u>https://assets.kpmg.com/content/dam/kpmg/pdf/2015/12/fintech-100-leading-innovators-2015.pdf</u> (Accessed on 30th April 2023)

Lai, K. P. Y. (2020). FinTech: The dis/re-intermediation of finance? In *The Routledge handbook of financial geography* (pp. 440–457). Routledge.

Lai, K. P. Y., & Langley, P. (2023). Playful finance: Gamification and intermediation in FinTech economies. *Geoforum*, 103848. DOI:10.1016/j.geoforum.2023.103848

Lai, K. P. Y., & Samers, M. (2021). Towards an economic geography of FinTech. *Progress in Human Geography*, *45*(4), 720–739. DOI: 10.1177/0309132520938461

Laidroo, L., & Avarmaa, M. (2020). The role of location in FinTech formation. *Entrepreneurship & Regional Development, 32*(7–8), 555–572.

Langley, P., & Leyshon, A. (2021). The platform political economy of FinTech: Reintermediation, consolidation and capitalisation. *New Political Economy*, *26*(3), 376–388.

Liu, F. H. M., Demeritt, D., & Tang, S. (2019). Accounting for sustainability in Asia: Stock market regulation and reporting in Hong Kong and Singapore. *Economic Geography*, *95*(4), 362–384. DOI: 10.1080/00130095.2018.1544461

Liu, H., Yao, P., Latif, S., Aslam, S., & Iqbal, N. (2022). Impact of green financing, FinTech, and financial inclusion on energy efficiency. *Environmental Science and Pollution Research*, 1–12. DOI: 10.1007/s11356-021-16949-x

Löfqvist, S., & Ghazoul, J. (2019). Private funding is essential to leverage forest and landscape restoration at global scales. *Nature Ecology and Evolution, 3*, 1612–1615. DOI: 10.1038/s41559-019-1031-y

Löfqvist, S., Garrett, R. D., & Ghazoul, J. (2023). Incentives and barriers to private finance for forest and landscape restoration. *Nature Ecology and Evolution*, *7*(5), 707–715. DOI: 10.1038/s41559-023-02037-5

Loizeaux, E. R. (2023). Trees made out of fintech: Valuing carbon and accumulating capital in China's Ant Forest. *Geoforum, 147*. DOI: 10.1016/j.geoforum.2023.103888

Macchiavello, E., & Siri, M. (2022). Sustainable finance and fintech: Can technology contribute to achieving environmental goals? A preliminary assessment of 'green fintech' and 'sustainable digital finance'. *European Company and Financial Law Review, 19*(1), 128–174. DOI: 10.1515/ecfr-2022-0005

Mansourian, S., & Vallauri, D. (2023). Categories of actors involved in tree planting by multinational corporations based in France, Switzerland and the UK. *Sustainable Development*, *31*(4), 2929–2937. DOI: 10.1002/sd.2559

McAfee, K. (1999). Selling nature to save it? Biodiversity and green developmentalism. *Environment and Planning D: Society and Space, 17*(2), 133–154. DOI: 10.1068/d170133

Menon, S., & Jain, K. (2021). Blockchain technology for transparency in agri-food supply chain: Use cases, limitations, and future directions. *IEEE Transactions on Engineering Management, 71*, 106–120. DOI:10.1109/TEM.2021.3110903

Milne, S. (2022). *Corporate nature: An insider's ethnography of global conservation*. University of Arizona Press.

Milne, S., & Mahanty, S. (2019). Value and bureaucratic violence in the green economy. *Geoforum, 98*, 133–143. DOI:10.1016/j.geoforum.2018.11.003

Mollick, E. (2014). The dynamics of crowdfunding: An exploratory study. *Journal of Business Venturing*, *29*(1), 1–16. DOI: 10.1016/j.jbusvent.2013.06.005

Nassiry, D. (2018). The role of fintech in unlocking green finance: Policy insights for developing countries (No. 883). *ADBI Working Paper*.

Neumann, R. P. (2004). Nature–state–territory: Toward a critical theorization of conservation enclosures. In R. Peet & M. Watts (Eds.), *Liberation ecologies: Environment, development, social movements* (pp. 195–217). Routledge.

Newell, P., & Bumpus, A. (2012). The global political ecology of the clean development mechanism. *Global Environmental Politics*, *12*(4), 49–67. DOI:10.1162/GLEP\_a\_00139

Nishant, R., Kennedy, M., & Corbett, J. (2020). Artificial intelligence for sustainability: Challenges, opportunities, and a research agenda. *International Journal of Information Management, 53*, 102104. DOI: 10.1016/j.ijinfomgt.2020.102104

Omarova, S. T. (2020). Technology v technocracy: Fintech as a regulatory challenge. *Journal of Financial Regulation, 6*(1), 75–124. DOI: 10.1093/jfr/fjaa004

Patterson. (2023). *Fintech and sustainability: ESG investing, green finance, and carbon neutrality*. Available at: <u>https://www.financemagnates.com/fintech/investing/fintech-and-sustainability-esg-investing-green-finance-and-carbon-neutrality/</u> (Accessed on 30th April 2023)

ProPublica. (2021). *The celebrity-backed green "fintech" company that isn't as green as it seems*. Available at: <u>https://www.propublica.org/article/the-celebrity-backed-green-fintech-company-that-isnt-as-green-as-it-seems</u>

PWC. (2016). *Blurred lines: How FinTech is shaping financial services*. Available at: <u>https://www.pwc.com/il/en/home/assets/pwc\_fintech\_global\_report.pdf</u> (Accessed on 30th April 2023)

Pye, O. (2019). Commodifying sustainability: Development, nature and politics in the palm oil industry. *World Development, 121*, 218–228. DOI: 10.1016/j.worlddev.2018.02.014

Rana, P., & Varshney, L. R. (2023). Exploring limits to tree planting as a natural climate solution. *Journal of Cleaner Production, 384*, e135566. DOI:10.1016/j.jclepro.2022.135566

Restoy, F. (2019). Regulating fintech: What is going on, and where are the challenges. *Bank for International Settlements*, 1–7.

Rizzi, A., Kessler, A., & Menajovsky, J. (2021). *The stories algorithms tell: Bias and financial inclusion at the data margins*. Center for Financial Inclusion, Accion.

Scheer, S. (2023). Fintech Vesttoo to slash jobs after fake collateral scandal. *Reuters*. Available at: <u>https://www.reuters.com/business/finance/fintech-firm-vesttoo-slash-workforce-amid-fake-collateral-2023-08-01/</u> (Accessed on 30th April 2023)

Schreier, M. (2012). Qualitative content analysis in practice. Sage.

Seymour, F. (2020). Seeing the forests as well as the (trillion) trees in corporate climate strategies. *One Earth, 2*(5), 390–393. DOI: 10.1016/j.oneear.2020.05.006

Starfinger, M. (2021). Financing smallholder tree planting: Tree collateral & Thai 'Tree Banks' – Collateral 2.0? *Land Use Policy, 111*, e105765. DOI: 10.1016/j.landusepol.2021.105765

Sullivan, S. (2013). Banking nature? The spectacular financialisation of environmental conservation. *Antipode, 45*(1), 198–217. DOI: 10.1111/j.1467-8330.2012.00989.x

Suri, T., & Jack, W. (2016). The long-run poverty and gender impacts of mobile money. *Science*, *354*(6317), 1288–1292. DOI: 10.1126/science.aah5309

Tedesco, A. M., Brancalion, P. H. S., Hepburn, M. L. H., Walji, K., Wilson, K. A., Possingham, H. P., Dean, A. J., Nugent, N., Elias-Trostmann, K., Perez-Hammerle, K. V., & Rhodes, J. R. (2023). The role of incentive mechanisms in promoting forest restoration. *Philosophical Transactions of the Royal Society B: Biological Sciences,* 378(1867), 20210088. DOI:10.1098/rstb.2021.0088

Thompson, B. S. (2017). Can financial technology innovate benefit distribution in payments for ecosystem services and REDD+? *Ecological Economics, 139*, 150–157. DOI:j.ecolecon.2017.04.008

Thompson, B. S. (2018). The political ecology of mangrove forest restoration in Thailand: Institutional arrangements and power dynamics. *Land Use Policy*, *78*, 503–514. DOI: 10.1016/j.landusepol.2018.07.016

Thompson, B. S. (2019). Payments for ecosystem services and corporate social responsibility: Perspectives on sustainable production, stakeholder relations, and philanthropy in Thailand. *Business Strategy and the Environment, 28*(4), 497–511. DOI: 10.1002/bse.2260

Thompson, B. S. (2022). Impact investing in biodiversity conservation with bonds: An analysis of financial and environmental risk. *Business Strategy and the Environment, 32*(1), 353–368. DOI:10.1002/bse.3135

Udeagha, M. C., & Ngepah, N. (2023). The drivers of environmental sustainability in BRICS economies: Do green finance and fintech matter? *World Development Sustainability, 3*, 100096. DOI: 10.1016/j.wds.2023.100096

UNEP. (2023). State of finance for nature: The big nature turnaround – Repurposing \$7 trillion to combat nature loss. Nairobi. DOI: 10.59117/20.500.11822/44278

Verra. (2023). Verra announces innovative, high-integrity afforestation, reforestation and revegetation methodology. Available at: <u>https://verra.org/verra-announces-innovative-high-integrity-afforestation-reforestation-and-revegetation-methodology/</u> (Accessed on 30th April 2023)

Vergara, C. C., & Agudo, L. F. (2021). Fintech and sustainability: Do they affect each other? *Sustainability, 13*(13), 7012. DOI: **10.3390/su13137012** 

West, T. A., Wunder, S., Sills, E. O., Börner, J., Rifai, S. W., Neidermeier, A. N., ... & Kontoleon, A. (2023). Action needed to make carbon offsets from forest conservation work for climate change mitigation. *Science, 381*(6660), 873–877. DOI: 10.1126/science.ade3535

Wojcik, D. (2021). Financial geography I: Exploring FinTech–maps and concepts. *Progress in Human Geography*, *45*(3), 566–576. DOI: 10.1177/0309132520952865

World Bank. (2022). *FinTech and the future of finance*. Available at: <u>https://thedocs.worldbank.org/en/doc/11ea23266a1f65d9a08cbe0e9b072c89-</u>0430012022/related/FOF-Executive-Summaries-Final.pdf (Accessed on 30th April 2023)

Zavolokina, L., Dolata, M., & Schwabe, G. (2016). The FinTech phenomenon: Antecedents of financial innovation perceived by the popular press. *Financial Innovation, 2*(1), 1–16. DOI: 10.1186/s40854-016-0036-7

Zhou, G., Zhu, J., & Luo, S. (2022). The impact of fintech innovation on green growth in China: Mediating effect of green finance. *Ecological Economics, 193*, 107308. DOI: j.ecolecon.2021.107308

Zook, M. (2023). Platforms, blockchains and the challenges of decentralization. *Cambridge Journal of Regions, Economy and Society, 16*(2), 367–372. DOI: 10.1093/cjres/rsad008

Zook, M. A., & Blankenship, J. (2018). New spaces of disruption? The failures of Bitcoin and the rhetorical power of algorithmic governance. *Geoforum, 96*, 248–255. DOI: j.geoforum.2018.08.023

**Figure 1.** Spatial distribution of FFF platforms headquarters (for simplicity, the diamonds reflects the country where the FFF is headquartered, rather than the city), and the countries in which tree planting activities occur (circles).

Alt text: World map showing the global footprint of various 'FFF' platforms. Coloured diamond icons indicate FFF headquarters, while circles show tree planting locations. Each company is represented by a unique colour, with a legend identifying the companies and their corresponding regions. Notable F include Ant Forest (China), Aspiration (USA), Bunq (Netherlands), Mastercard Priceless Planet Coalition (USA), Flowe (Italy), GForest (Philippines), Mogo (Canada), Tred (UK), and TreeCard (UK). Tree planting activities span across countries in Africa, Asia, the Americas, and Europe.

**Figure 2:** Flows of capital and information across the FFF value chain, showing how FFF platforms can engage both retail clients and institutional clients in financing tree planting, but that the tree planting itself relies on a series of subcontractors.

Alt text: Flowchart illustrating the financial and informational relationships in FFF. Starting from the left hand side of the chart, retail and institutional clients provide capital to fintech companies through everyday spending or donations. The middle of the chart indicate FFF allocate funds to project developers, who outsource tree planting to project implementers (planters). On the right hand side of the chart, we show that planters execute the planting, resulting in trees planted. Project developers and planters report activities back to fintechs. Independent verifiers assess the output and impact, with information flowing back through the system. Arrows denote flows of capital (solid lines) and information (dashed lines). Client interaction with FFF is mediated by app interfaces, dashboards, and reporting.

**Figure 3.** A flowchart of how AntForest and GForest engage their users to plant trees through gamified and user interface and experiences (Source: The Authors) Alt text: Flowchart titled "Workflow of AntForest and GForest" describing six steps: **Step 1:** Users sign up for Alipay or GCash and activate the Ant Forest or GForest function. **Step 2:** Users earn points by making 'green' purchases using the app, encouraging app-based transactions. **Step 3:** Users collect daily 'Green Energy Points' or 'Green Energy', which can be stolen by others if not promptly collected, promoting daily engagement through gamification. **Step 4:** After accumulating enough points, users can plant a virtual tree via the app, alone or jointly with others. **Step 5:** Users select a tree species to plant; Ant Forest users can also choose the planting location. **Step 6:** Alipay and GCash plant a real tree corresponding to each virtual tree planted.

**Figure 4.** Relationships between the four 'promises' of FinTech for scaling tree planting efforts, denoting the challenges (gold arrows, bold text) and opportunities (green arrows, non-bold text).

Alt text: A circular diagram illustrating the interactions between four purported promises of FFF: increasing investments towards tree planting, enhancing inclusivity, fostering transparency, and enhancing democracy. Arrows denote directional relationships, colour-coded as either trade-offs or challenges (brown), and synergises or opportunities (teal dashed lines). Each connection is labeled with corresponding effects or issues, such as the challenge of providing full transparency, information asymmetry, or opportunities for broader participation and increased confidence, which is elaborated in the main text. The diagram

emphasises the complexity of balancing inclusive and democratic decision-making with efficient investment and transparency demands.