The new service development process of green FinTech innovation: A multi-case study

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A B S T R A C T

In light of increasing global challenges like climate change, carbon neutrality, and biodiversity loss, the need for sustainable solutions is essential. Green FinTech innovation, which combines financial resources, services, and technologies, has become a significant area of focus for addressing these issues. However, despite growing interest from various stakeholders, progress towards sustainable development remains slow due to fragmented academic knowledge. This study aims to bridge this gap by offering practical guidelines for those involved in green FinTech innovation. By examining the new service development process, including both the front-end and back-end stages, the study will identify key influencers such as customers, organizations, and partners. Semi-structured interviews will be conducted with three green FinTech case studies in Thailand, specifically focusing on rental electric bike services, energy trading systems, and solar rooftop platforms. The research will investigate the concepts, methods, and critical success factors that drive the innovation processes of these projects through a comparative multi-case study. The findings will reveal different paths for B2B and B2C green FinTech innovation, emphasizing the importance of external factors. Successful innovation requires a thorough understanding of customer behavior, beyond just pro-environmental tendencies. These insights aim to accelerate green FinTech innovation in emerging economies and underscore the need for further quantitative research to validate these findings. This research will provide valuable insights for policymakers, financial institutions, and innovators, supporting the advancement of sustainable development through green FinTech solutions.

1. Introduction

The 26th United Nations Climate Change Conference (COP26) in 2021 gathered global leaders and experts to develop strategies for addressing climate change and limiting the temperature increase to 1.5°C (Dwivedi et al., 2022). COP26 highlighted the connection between finance, sustainability, and technology, leading to the concept of "Green FinTech." According to ISO and UNEP (Fig. 1), Green FinTech is a part of Sustainable FinTech, integrating finance and technology to enhance customer benefits in usability, efficiency, transparency, and automation, focusing on climate change mitigation, adaptation, and environmental sustainability through financial products and services. It significantly contributes to environmental sustainability by using FinTech innovations to influence consumer preferences towards environmentally friendly options, offering benefits such as increased convenience, reduced carbon footprint, and greater transparency in green behaviors (Dwivedi et al., 2022).

In response, various public, private, and non-governmental initiatives are accelerating the financial movement for sustainable development. The financial services industry plays a crucial role in promoting a greener future facilitating green investments globally. FinTech has proven its capability to address long-standing challenges in the sector, balancing impact objectives (e.g., increasing financial resources for sustainable development) with business objectives (e.g., maintaining financial returns for long-term impact) (He et al., 2019). Digital financial technology also promotes carbon

mitigation and adaptation. In the past three years, hundreds of Green FinTech startups have emerged worldwide, and many organizations are studying their role in transforming the financial system to better address climate change, develop comprehensive climate risk approaches, and enhance adaptation and resilience. Today, FinTech represents more than half of all global startup investments, but Sustainable FinTech is still in its early stages, with less than 8% of FinTech founders identifying with this category. However, startups focusing on climate change are growing rapidly.
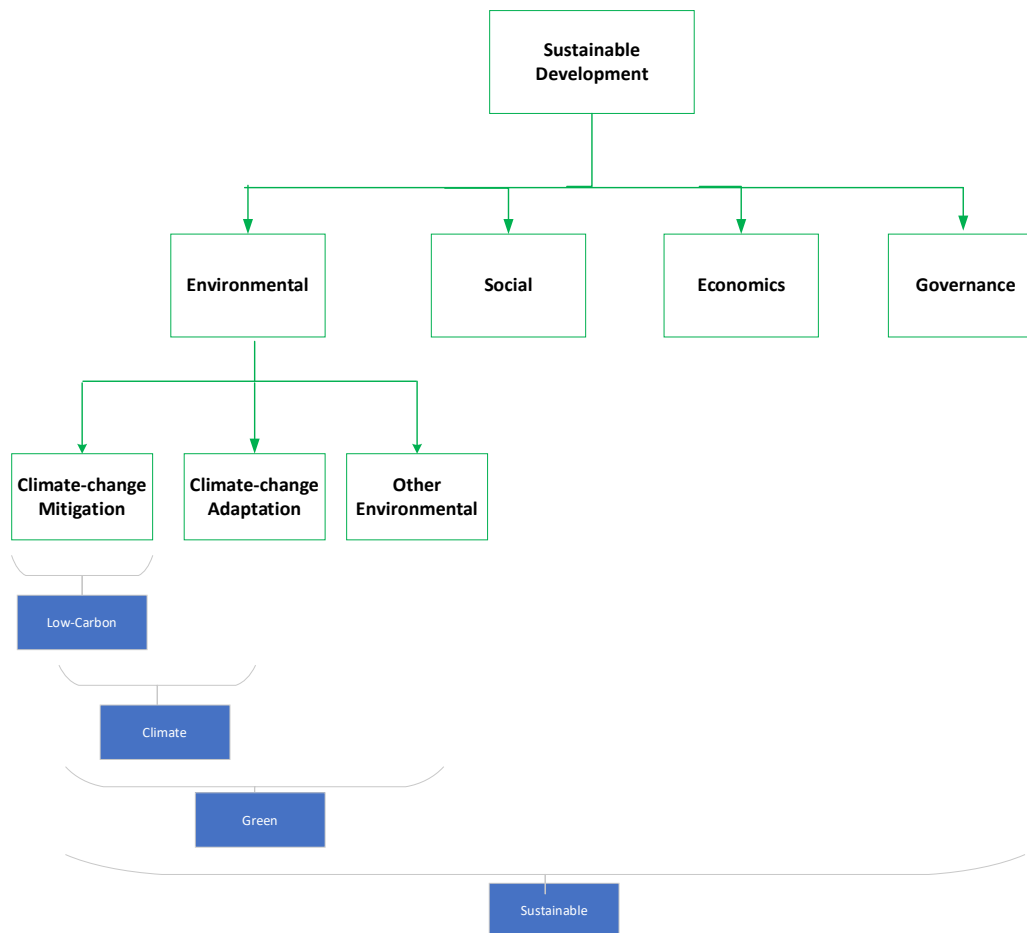

Fig. 1: Inter-relationship of sustainable, green, and climate finance

According to the Green Digital FinTech Alliance (GDFA), introducing nudges and incentives on digital platforms can significantly change the behavior of tech-savvy consumers. This could help mitigate global climate change and reduce public transport emissions by 8.6%. GDFA emphasizes that green mobile platforms can effectively inform and motivate citizens to reduce carbon emissions. Additionally, these platforms can overcome obstacles to scaling sustainable finance and foster innovation that promotes sustainable investments in the real economy. Transitioning to a low-carbon economy and meeting the Paris Agreement's goals will require global financial investments of $3-5 trillion annually over the next 30 years to decarbonize ten key sectors responsible for 75% of global emissions. This represents a five to eightfold increase from the current $600 billion market for climate finance.

Thailand is proactive in climate action, with the government implementing extensive climate change adaptation and mitigation plans. Thailand's growing economy and rich environment have driven these efforts. Thailand was one of the first Southeast Asian countries to submit its Nationally Determined Contribution (NDC), aiming to limit global temperature rise to below 2°C and reduce greenhouse gas emissions by 25% by 2030. National climate action plans in Thailand include the 20-year National Strategy, the 12th National Economic and Social Development Plan, the National Environment Quality Promotion and Conservation Policy and Plan (2017-2036), the Environmental Quality Management Plan (2017-2021), and the Climate Change Master Plan (2015-2050), which promotes mitigation, adaptation, green growth, and international cooperation (Misila et al., 2020).

The Bank of Thailand has introduced "Sustainable Finance Initiatives" with a green taxonomy guiding financial institutions to support the economy's transition to sustainability and manage climate-related financial risks. The Stock Exchange of Thailand launched the Thailand Sustainability Investment (SETTHSI) index in 2015. By 2022, 170 companies met the criteria, focusing on sustainability and innovation in their operations and investments. These companies will drive the development of necessary infrastructure and enable Green FinTech among corporates, startups, and

financial institutions. Regulators believe that Thailand's long-term competitiveness and profitability will depend on the success of its sustainable finance ecosystem, which will encourage stakeholders to improve the framework and methodologies collectively. The Bibliometric Analysis in Fig. 2 shows high research interest in "green FinTech," "green innovation," "New Service Development," and "Innovation Process," with significant contributions from researchers in China, the USA, Vietnam, and Pakistan. The research is divided into three main areas: 1) Green innovation related to company competitiveness and sustainable manufacturing supply chain management, 2) designing sustainable products and services, and 3) developing green innovation and investment in China's industrial estates. There is a lack of empirical studies on the development of green FinTech innovation processes in emerging countries.
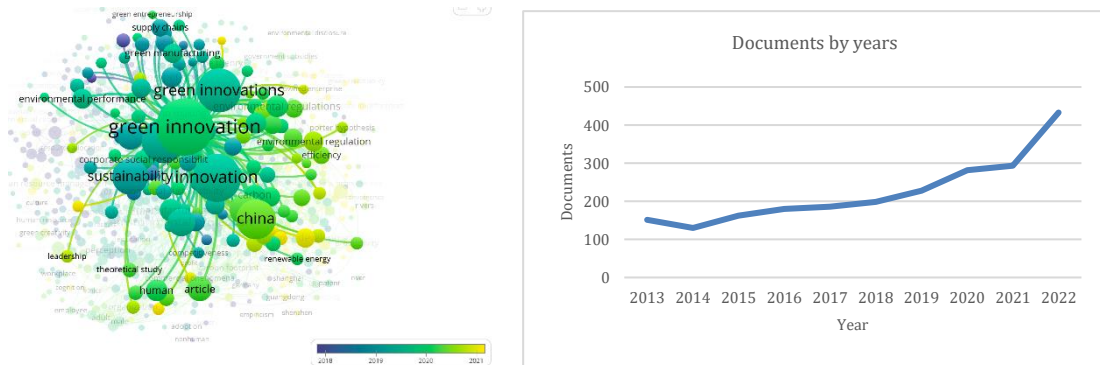

Fig. 2: Bibliometric analysis of keywords

The comprehensive exploration of the new service development process within green FinTech innovation is rarely studied. While previous research has addressed aspects of green innovation, green finance, or FinTech separately, this study uniquely integrates these domains to provide a holistic understanding. By conducting a comparative multi-case study of three distinct green FinTech projects in Thailand, we uncover nuanced insights into the innovation processes, stakeholder dynamics, and critical success factors. This novel approach contributes valuable knowledge to the emerging field of green FinTech, offering practical guidelines for stakeholders and potentially accelerating sustainable financial practices globally. The objectives of this paper are as follows:

- To understand the concept and structure of Thailand's Green FinTech innovation processes. This includes examining what the innovation process looks like, how it is influenced by and interacts with stakeholders in the ecosystem to co-create green FinTech innovations, and identifying its success factors, drivers, and barriers. Insights from the Green FinTech Innovation Case Study in Thailand will provide guidelines and recommendations for creating green FinTech innovations to address green transition challenges in the real sector.
- To fill the academic gap by integrating relevant theories and concepts, including a multidisciplinary review analysis of previous research on the green FinTech innovation process. This serves as a basis for the multi-case study and as empirical results for exploration and comparison.
- To apply the findings to better support the stimulation and development of green FinTech

innovations, thereby contributing to the financial investment movement for climate-change solutions and enhancing the potential for sustainable competition and green businesses in Thailand.

These objectives will be achieved by answering the following research questions:

- RQ1: What does the innovation process for green FinTech innovations look like?
- RQ2: What lessons have been learned from the critical success factors, drivers, barriers, and suitable elements of the ecosystem that enable the development of guidelines for successful green FinTech?

2. Literature review

Previous studies have explored green innovation, green finance, and FinTech, each playing a key role in developing new financial services, especially in the context of climate change. Both large and small FinTech companies actively promote green innovation (Ashta, 2023; Liu et al., 2023). The rise of climate FinTech or green FinTech has introduced new business models aimed at sustainable development. These innovative FinTech solutions improve the flow of financial resources to sustainable projects and help meet ESG standards (Jha et al., 2022). The development of FinTech has been shown to reduce information asymmetry, ease financing constraints, and boost investment in green innovation (Ruman et al., 2022). Overall, the multi-case study approach highlights the varied strategies and impacts of FinTech firms in promoting green innovation and sustainable development within the financial services industry.

Research on the innovation process of green FinTech is limited. Current research mostly covers general FinTech innovation and only a few aspects of its process. This chapter presents the theories, concepts, and models deemed suitable to describe the green FinTech innovation process, which was used to guide interview questions and case selection. The chapter begins with a classification of green FinTech, an overview of innovation process theory development, and an examination of the critical success factors, drivers, and barriers. These multidisciplinary theories are applied to analyze the empirical data in this study.

2.1. Green FinTech classification and definition

Due to their blended-value mission, green FinTech innovations can be applied to social enterprises, which are organizations that address social needs through business activities (Austin et al., 2006; Haugh, 2007). Several groups, including GDFA, New Energy Nexus, and CommerzVentures, are analyzing FinTech from a sustainability perspective. We have chosen to use the Green FinTech Classification developed by GDFA (greendigitalfinancealliance.org), as follows:

1. Green digital payment and account solutions
- Definition: Solutions that integrate green features into the payment experience to promote sustainable behaviors.
- Use cases:
o Automated carbon, plastic, or water footprint accounting based on transaction data.
o Automated offsetting of green externalities.
2. Green digital investment solutions
- Definition: Platforms providing automated, algorithm-driven green financial planning and investment services with minimal human supervision.
- Use cases:
o Retail algorithmic trading focusing on green assets.
o Automated green investment advice.
o Automated green portfolio allocation.
o Risk assessment according to environmental criteria.
3. Digital ESG data and analytic solutions
- Definition: Solutions for automated green data collection and analytics for finance, including automated green asset rating and indexing.
- Use cases:
o Credit scoring algorithms that integrate green data into credit decisions.
o Automated ESG rating of companies and funds.
o Digital green indexing.
4. Green digital crowdfunding and syndication platforms
- Definition: Digital platforms for capital raising from individuals or institutional investors to finance new green ventures or projects.
- Use cases:
o Green equity crowdfunding.
o Green loan crowdfunding.

o Green donation crowdfunding.
5. Green digital risk analysis and insurtech
- Definition: Solutions to optimize green insurance products and services and minimize physical climate and nature-related risks.
- Use cases:
o Automated risk evaluation and monitoring tools.
o Digital green insurance.
o Dynamic pricing and underwriting of green assets.
o IoT for green asset insurance (e.g., real estate, electric vehicles).
o Smart contracts for green claims handling.
6. Green digital deposit and lending solutions
- Definition: Digital savings solutions to finance environmentally beneficial projects and loans linked to green behaviors.
- Use cases:
o Green digital loans.
o Green-linked or transition loans with automated monitoring.
o Green digital mortgages.
7. Green digital asset solutions
- Definition: Tokens, cryptocurrencies, and blockchain capital market infrastructure built for green use cases.
- Use cases:
o Green utility tokens rewarding lower carbon emissions.
o Green asset tokens (e.g., tokenized carbon credits, biodiversity offsets).
o Green cryptocurrencies designed for spending on green products.
o Green Security Token Offering (STO) issuance platforms for green products.
8. Green regtech solutions
- Definition: Applications of technology-enabled innovation for regulatory, compliance, and reporting requirements implemented by regulated institutions or financial supervisory authorities.
- Use cases:
o Using digital technology to analyze disclosed green and financial data to automatically calculate a green taxonomy alignment percentage of a financial product (e.g., a fund).
o Leveraging Natural Language Processing (NLP) capabilities for green data analysis.

This classification aims to promote a peer-reviewed framework covering a broad array of use cases, aligning closely with existing FinTech taxonomies used in market assessments. This ensures that FinTech projects can identify with categories reflecting standardized ways of classifying FinTech market segments.

Additionally, literature analysis shows five significant patterns in green FinTech-related domains: 1) Provider Type (banking or insurance solutions), 2) Interaction Type (B2B, B2C), 3) Direct Financial Process (specific green FinTech processes like investment and payments), 4) Indirect Financial Process (use of green FinTech in other industries like energy, agriculture, or mobility), and 5) SDG-related solutions (Puschmann et al., 2020).

A green FinTech innovation is defined as a novel, technologically enabled solution related to financial services developed by enterprises, start-ups, technological firms, or traditional financial service providers to increase the flow of financial capital for climate-change issues (Ranchber, 2018).

Furthermore, the definitions and rules of green taxonomy from regulators are crucial in determining which economic activities are environmentally sustainable and in setting standards to avoid "greenwashing" or false claims of environmental responsibility. For instance, the EU Taxonomy mandates that activity must contribute to one of six environmental objectives: (1) climate change mitigation, (2) climate change adaptation, (3) sustainable use and protection of water and marine resources, (4) transition to a circular economy, (5) pollution prevention and control, and (6) protection of biodiversity. In Thailand's Taxonomy, the initial phase focuses on the environmental objective of climate change mitigation.

2.2. Green FinTech's new service development process and its ecosystem

A multi-disciplinary approach, combining concepts from new service development, the FinTech ecosystem, Open Innovation (OI), and digital integration, is expected to help us understand how new Green FinTech innovations interact with various actors in the ecosystem, from the initial idea to market launch.

2.2.1. Green FinTech's new service development process

According to Menor et al. (2002), globalization, rapidly advancing technologies, and unexpected risks pressure companies to compete by offering new services rather than developing new physical products. This has increased the importance of new service development (NSD) and service innovations (Table 1), treating NSD as the entire process of creating a service offering (Zomerdijk and Voss, 2011). Most NSD models are based on the new product development (NPD) framework, which follows a linear sequence of activities. The Stage-Gate model by Cooper (1990) is commonly used in NSD processes (Table 1). These models have certain gates for decision-making based on information from previous stages and follow a linear progression. However, their sequential nature makes them costly, time-consuming, and inflexible, making them unsuitable for recent service innovations.

Johnson et al. (2000) proposed a more comprehensive NSD model that is nonlinear and iterative, allowing stakeholders to provide feedback and iterate after the market launch stage. This model focuses on service design using tools and techniques to structure service concepts and introduces a process with four main stages: design, analysis, development, and launch. The nonlinear nature of this model allows interdependence between design and development, enabling co-creation with stakeholders for new insights.

The NSD process cycle (Fig. 3) provides a flexible roadmap for development teams, reducing the need for centralized management. Enablers positively influence the NSD cycle, allowing service developers to design delivery systems tailored to customer needs (Johnson et al., 2000).

The design phase involves creating and screening new service concepts, setting objectives, and developing and testing concepts. The analytical stage includes a detailed business analysis to decide whether to continue the project. The development phase focuses on designing the service, related processes, systems, and marketing plans, including pilot testing. The launch stage includes full launch activities for customers and post-launch inspections. The NSD process is highly repetitive and nonlinear, with steps occurring in various orders and often repeated multiple times before the final service is developed.

2.2.2. Digitally integrated open innovation ecosystem

In addition to a solid NSD process, understanding FinTech's evolution requires examining three perspectives: its ecosystem (skills, resources, systems, and capabilities from each actor), Open Innovation (inside out, outside in, and coupled OI), and digital integration (key technologies include mobile technology, blockchain, AI, IoT, and Big Data).

A suitable ecosystem (Fig. 4), where each stakeholder supports each other to achieve mutual goals, is essential for developing new Green FinTech. Applying a general FinTech ecosystem theory, a stable and interdependent FinTech ecosystem contributes to the industry's growth (Lee and Shin, 2018). This ecosystem includes FinTech start-ups, technology developers, government, financial customers, traditional financial institutions, financial services authorities, and regulatory bodies (Alaassar et al., 2020). These entities help develop innovations, facilitate resource accessibility, and contribute to ecosystem activities.

FinTech companies transform using Open Innovation (OI) as their main approach, involving deep inter-organizational and intra-organizational ecosystems that provide the necessary assets for successful innovation. The financial sector's neo-ecosystems consist of a consortium of organizations, individuals, and digital technologies that mediate interactions within the ecosystem, making it challenging to control the impact on OI (Latour, 2005; Chen and Hung, 2016; Jacobides et al., 2018). Consequently, FinTech firms continually seek to understand the role of digital integration in OI and manage ecosystem interactions for all stakeholders in the financial sector.

Academics have recently focused on the role of digital integration in managing FinTech OI. Boratyńska (2019) studied how the economic and financial characteristics of digital financial

technology impact value creation in financial services, providing insights into tools that enable stakeholders to create value in FinTech. Some scholars suggest that companies should involve not only customers but also other entities like user communities, suppliers, partners, competitors, universities, and venture capitalists in the co-creation process for NPD or NSD (Bell and Loane, 2010; Chesbrough, 2011; Fasnacht, 2009).

This approach provides an overview of how financial institutions use open innovation mechanisms to develop new services adapted to changing market environments and trends. It also examines factors that enable or hinder the successful application of OI in the financial industry. Initially, incumbents responded to the FinTech phase by waiting out or attacking new market entrants, but

the environment has recently shifted towards a more collaborative approach based on open innovation. Regulatory initiatives (e.g., open banking) further encourage this transition, paving the way for FinTech-enabled ecosystems.

FinTech innovation from a customer perspective shows how integrating digital technologies can offer value. IoT enables more devices to join financial services (e.g., payments or insurance), and Big Data from these smart devices can improve products and services for customers. AI and machine learning (e.g., robo-advisors, loan origination) are significant game-changers for modern finance. Newly emerging Web 2.0 applications enhance connections and collaboration between firms and their environments (Rialp et al., 2005; Sawhney et al., 2005).

Table 1: Service innovation's NSD model studies (Johnson et al., 2000; Trott, 2017)

References	NSD model study	NSD stages
Bowers (1989)	Selected stages from the NPD model	8-stage: Business strategy, new service strategy, idea generation, concept development, business analysis, service development, marketing, and commercialization
Cooper (1990)	Stage-gate model's NPD model	5 stages: Assessment, investigation, develop, testing and launch
Scheuing and Johnson (1989)	Linearity models of holistic NSD process	15 stages: New strategy, idea generation, idea screening, concept development, concept testing, business analysis, project authorization, service design, personnel training, service testing, marketing, launch, and post-launch review
Tax and Stuart (1997)	Linearity models of holistic NSD process	7 stages: Audit, assess concept, define process, define participant, define facilities, assess impact, asses internal capabilities
Johnson et al. (2000)	Nonlinearity NSD process cycle model	4 stages: Design, analysis, develop, launch

Fig. 3: New service development process adapted from Johnson et al. (2000)
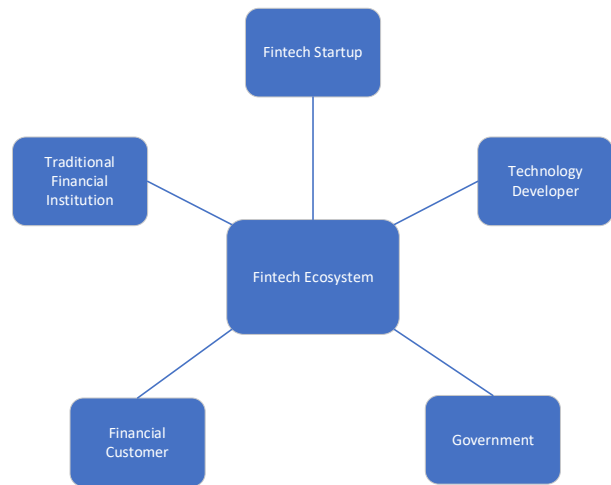

Fig. 4: FinTech ecosystem (Lee and Shin, 2018)

2.3. Critical success factors of new service development and its driver and barriers

Due to the scarcity of Green FinTech research, we focus on academic research on new service innovation in financial services. Improving the customer experience is key to the success of new services. Cooperation and innovation are necessary to align new services with business resources and enhance service quality. Management support, strategy, and communication are also crucial for providing successful financial services.

Several authors have identified critical success factors in the financial service sector (Shah Alam et

al., 2011; De Brentani, 1995; Konu, 2015; Thanapongporn et al., 2021). The key factors include:

- Climate of cooperation and innovation.
- Customer needs, experience, and involvement: Emphasizing understanding and meeting customer expectations.
- Resources and capabilities: Efficient allocation and use of resources and capabilities.
- Structured plan: Implementing an organized plan for service delivery.
- Management support: Active involvement and support from management.

- Team enthusiasm: Motivated and enthusiastic team members.
- Market knowledge: Deep understanding of market dynamics.
- Strategy alignment and IT communication: Aligning strategies with IT capabilities and ensuring effective communication.

Additionally, the proposed conceptual model of "7C" critical factors impacting NSD success includes:

- Corporate strategy and organizational culture supporting service innovation.
- Customer: Understanding the needs of existing customers, prospects, and internal customers like frontline employees.
- Collection of useful data for service development.
- Capabilities: People, new service processes, service delivery systems, technology, knowledge management, and project management.
- Creativity: Supporting personal and organizational creativity.
- Collaboration: Involving internal and external organizations, cross-functional teams, and training and motivation programs in the NSD process.
- Communication: Efficient communication during the NSD process with frontline employees and customers.

Drivers and barriers have been identified in research on general FinTech innovation processes (Ranchber, 2018) as follows:

- Drivers:
- Increased outsourcing of financial business functions (Puschmann, 2017; Gomber et al., 2017).
- Technology development and digital transformation (Punschmann, 2017; Gomber et al., 2017; Zavolokina et al., 2016; Haddad and Hornuf, 2019; Weichert, 2017).
- Unfulfilled customer needs and market incompleteness (Gomber et al., 2017; Weichert, 2017; Punschmann, 2017; Zavolokina et al., 2016; Haddad and Hornuf, 2019; Thanapongporn et al., 2023).
- Macroeconomic conditions (Zilgalvis, 2014; Haddad and Hornuf, 2019; Zavolokina et al., 2016; Weichert, 2017).
- Social challenges (Arena et al., 2018).
- Venture capital investors (Haddad and Hornuf, 2019).
- Regulatory frameworks (Punschmann, 2017; Haddad and Hornuf, 2019).
- Barriers:
- Lack of access to funding (Arena et al., 2018; Zilgalvis, 2014).
- Hybrid missions (Arena et al., 2018).
- Information asymmetries and lack of recognized impact measurement frameworks (Arena et al., 2018).
- Regulatory frameworks (Zilgalvis, 2014; Gomber et al., 2017; Zavolokina et al., 2016; Haddad and Hornuf, 2019).

Research on general financial innovation indicates that unmet needs or market incompleteness, such as information asymmetries, drive financial innovation (Zavolokina et al., 2016). FinTech innovations succeed by better fulfilling these needs than traditional financial service providers (Gomber et al., 2017). The financial crisis has made the younger, tech-savvy generation more skeptical of traditional providers and more open to trying new FinTech solutions (Weichert, 2017).

Regarding barriers, FinTech innovations often struggle to secure funding. Haddad and Hornuf (2019) found that the availability of venture capital positively influences the emergence of FinTech innovations. Social tech start-ups may not generate high enough returns to satisfy investors compared to high-tech start-ups, as profits are often reinvested in the organization rather than returned to shareholders. Flexible market regulations positively influence FinTech innovation. In response, countries like Singapore, Hong Kong, and London have created regulatory "sandboxes" to lower entry barriers and stimulate innovation in FinTech.

3. Research methodology

Case studies provide detailed empirical insights based on various data sources (Yin, 2014). Using multiple case studies increases external validity and helps prevent researcher bias. In this study, interviews were the primary data source, supported by secondary data from public relations materials like newspaper articles, websites, and social media. Three Green FinTech startups participated in the study.

Semi-structured interviews were chosen over participant observation because they allowed the researcher to gather data on the innovation process before and after the interview (Bryman and Bell, 2011). This method also enabled direct data collection from actors involved in the process, capturing their perspectives, perceptions, and experiences. Semi-structured interviews were ideal for case-study research because they allow for adaptive questioning based on respondents' answers and follow-up questions when needed (Taylor et al., 2015).

According to Yin (2014), an exploratory approach is suitable when previous research on a phenomenon is limited. This is the case with general FinTech innovation (Zavolokina et al., 2016; Gomber et al., 2017) and green FinTech innovation processes in particular. The researcher used a deductive approach, starting with established theories and concepts from previous literature to guide the data collection and interviews (Bryman and Bell, 2011). This approach allowed for revising the theoretical framework to better fit the data.

The choice of a case study design depends on understanding why or how a phenomenon works and the need for an in-depth understanding of the phenomenon and its real-life context. The research questions in this study require an in-depth

description of the "Green FinTech innovation process," including its appearance, influencing factors, and how these factors and ecosystem actors affect the process (Yin, 2014).

A three-step research procedure was adopted to analyze the new service innovation development process of Green FinTech innovations. The steps included:

1. Literature review and secondary data analysis: Reviewed literature and secondary data on Green FinTech to develop a theoretical lens and set up semi-structured interview questions. The questions focused on new service development patterns and the Green FinTech innovation ecosystem, from the fuzzy front-end to the back-end process. The relationship and interaction between each actor, as well as their critical success factors, drivers, and barriers in the ecosystem, were investigated. Professors reviewed the questions to ensure they matched the research questions and conceptual framework (Fig. 5).

2. Search for qualified key informants: Selected key informants who matched four inclusion criteria: (1) support customer interaction with financial or non-financial institutions, (2) connect to customer processes in financial services or another industry's ecosystem, (3) supported by digital technology, and (4) impact on climate-related Sustainable Development Goals (SDGs 7, 11, 12, 13, 14, or 15). Informants needed detailed insights into the innovation process (Tables 2 and 3).

3. Data collection and analysis: Identified and analyzed one Green FinTech solution from a tech startup, a financial institution, and a government enterprise. Data collection occurred from July 2021 to November 2022. The solutions were analyzed and mapped to the classification model from the literature review. Interview contents were transcribed, coded by categories, and organized into themes based on theories from the literature review. Cross-case synthesis (Yin, 2014) was applied to identify patterns within and between cases, enabling analytical generalization. Each case study was analyzed individually and compared with others. Secondary data from the literature review and startup websites supported the interviews and provided additional insights.

For context, Thailand's supportive infrastructure for stimulating Green FinTech innovation involves initiatives from startups, public corporations, government enterprises, and financial institutions. This development is driven by regulatory encouragement, young customers' preferences, the economic recession, and the pandemic.
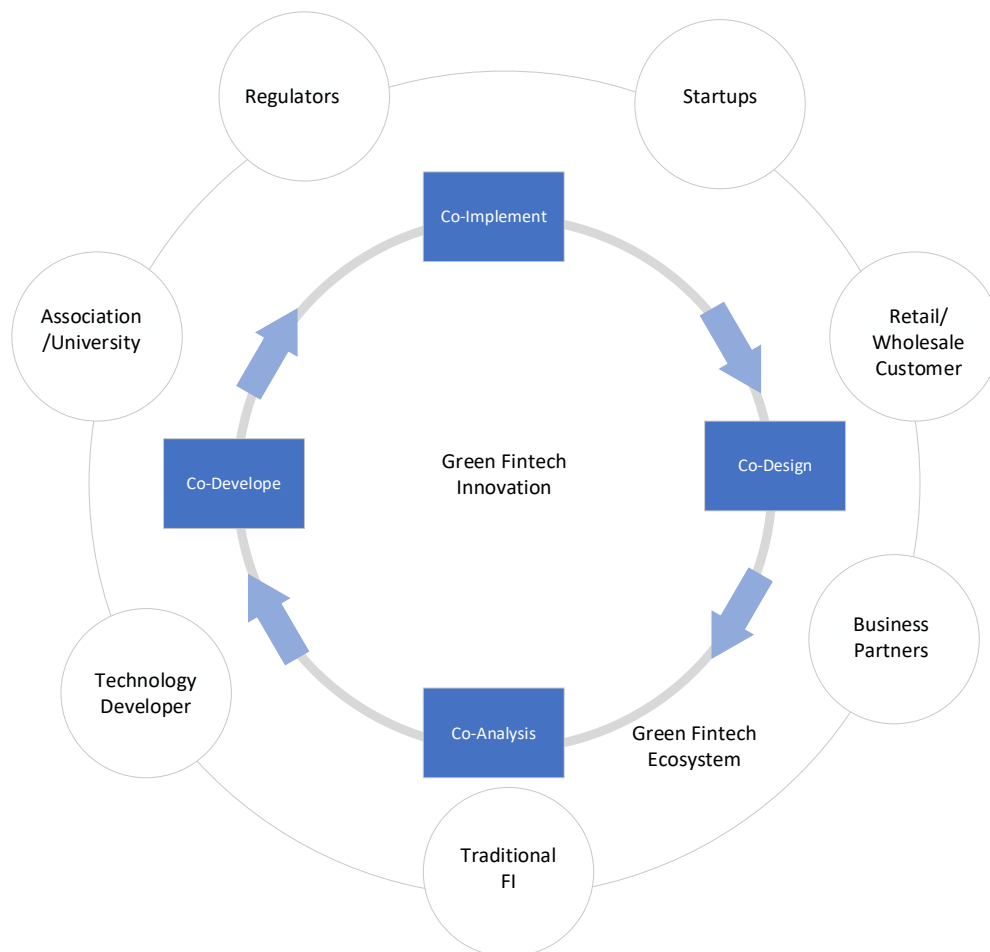

Fig. 5: Conceptual framework of green FinTech NSD process and its ecosystem

Table 2: Key informants descriptions

Green FinTech	Description	Impact on change mitigation	Meeting type	Interviewee	Type
Project A	The "Rental EV Bike Service for Delivery Riders" project was initiated in 2020 by a small, energetic team at a leading financial institution in Thailand. Their goal is to provide a pre-paid rental service for electric bikes (EV bikes) with a battery-swap station, targeting a new segment of budget-conscious customers. This service aims to promote decarbonized transportation through their mobile banking app and branches	Influencing consumer choice	Online meeting	Project manager	B2C
Project B	The "Carbon Credit/Renewable Energy Trading Platform" was initiated in 2019 by a tech company in Thailand, founded by an individual with high blockchain skills and experience in Silicon Valley. Their goal is to establish the first renewable energy exchange in this region for Thailand	Carbon pricing	Online meeting	MD and founder	B2B
Project C	The "Solar Rooftop Marketplace" project began in 2019, led by a young and energetic team of engineers in the innovation and digital business unit of a government enterprise in Thailand. Their goal is to promote the renewable energy prosumer concept among Thai consumers	Influencing consumer choice	Online meeting	Project manager	B2C

Table 3: Green FinTech classification

Green FinTech	GDFA's classification	Digital technology	Climate-change solution	Financial service/role
Project A: "EV bike rental platform for rider"	Green digital payment	Big data, mobile technology	Carbon mitigation	Financial incentive/direct
Project B: "Energy trading platform"	Green digital asset solution	Blockchain and AI	Carbon pricing and offsetting	Trading and settlement/indirect
Project C: "Solar rooftop platform"	Green digital lending and investment	Big data, mobile technology	Carbon mitigation	Lending and investment/indirect

4. Findings and discussion

4.1. Green FinTech classification and definition

Based on the analysis of Projects A, B, and C in Thailand discussed in this paper, green FinTech refers to innovations in financial technology that can be provided by both financial and non-financial institutions. These innovations support business-to-business (B2B) and business-to-consumer (B2C) interactions in financial services, including settlement and payments, loans and investments, incentives, and indirect financial services across various sectors such as energy. These innovations aim to develop services, processes, or infrastructures that support climate change solutions. The classification from the Global Digital Finance Association can be effectively applied to categorize green FinTech solutions in Thailand, helping to better understand their potential benefits and risks in the future.

4.2. Pattern of green FinTech's NSD

According to Johnson et al. (2000), we did not find all 4 main stages and 13 detailed stages in formalized sequences in the Green FinTech projects A, B, and C (Table 4). However, we identified stages in two New Service Development (NSD) patterns:

1. Proactivity-driven NSD pattern: This pattern is observed only in Project B. The founder, with extensive experience in blockchain and API use cases from working at a start-up in Silicon Valley, foresaw a business opportunity in renewable energy trading for Thailand. He decided to invest his company's funds to develop the exchanges, pending regulatory approval. We identified three stages and three sub-stages in Project B's NSD pattern:

- Idea generation → Idea screening → Definition of problems
- Business analysis → Service concept development → Testing → Launch

The founder's industry connections and trust earned from previous work allowed him to confidently invest in addressing industry pain points, such as acquiring renewable energy (Scope 2) and carbon credits. This Green FinTech was co-created with stakeholders, moving from service concept development to launch through a regulatory sandbox model and revenue model with the association.

2. Strategy-driven NSD pattern: This pattern is found in Projects A and C. Both teams were assigned new strategies to incorporate green and sustainable concepts into their existing businesses.

- Project A: Initiated by a small team in a leading financial institution, targeting small-pocket customers, especially delivery riders, during the COVID lockdown. They collaborated with a medium-sized EV bike manufacturer to promote decarbonized mobility and offered a new value proposition of "pre-paid rental fees" to delivery riders.
- Project C: Initiated by a young team in a government enterprise aiming at a new business line in renewable energy. Despite Thailand's year-round solar potential, solar rooftops were not popular. Market research revealed a need for solar rooftop prosumers, but knowledge and capital were major pain points. They co-created a platform with a trusted vendor and partner bank to provide information on setup fees, electricity purchase prices, and special loan conditions.

In this NSD pattern, we identified four sub-stages and three stages:

- Service concept development → Idea generation → Idea screening → Testing
- Business analysis → Launch

Projects A and C began with a defined service concept and proceeded to other stages. Both organizations saw new opportunities in green business, leading to shorter development periods due to clear management support and innovation boundaries. Compared to Ranchber (2018) and Puschmann et al.'s (2020) NSD of Green FinTech in Germany and Switzerland, which were mostly proactivity-driven and funded by venture capital or large corporations, two out of three Green FinTech cases in Thailand were strategy-driven NSD patterns initiated by innovation teams in large organizations. Thailand's large corporations and financial institutions seem to develop their own Green FinTech solutions due to their openness and abundant resources in talent, capital, and networks.

4.3. FinTech ecosystem

Project A involves three key actors: suppliers, customers, and universities. It employs the open innovation concept in the stages of service concept development, business analysis, service design and testing, and launch. Project A shares resources, features, and benefits from new revenue streams with these key actors.

Project B includes regulators, associations, and financial institutions (FIs) as its key actors. It also applies open innovation in the stages of service concept development, business analysis, service design and testing, and launch. Project B benefits from obtaining a license to operate from the regulators, settlement features from FIs, and a customer base from the association. FIs share new revenue streams, while association members and regulators gain decarbonized solutions from Project B.

Project C has five key actors: suppliers, startups, customers, FIs, and universities. It applies open innovation in the stages of service design and testing, business analysis, and launch. Project C benefits from capital provided by FIs, high-quality solar cells from suppliers, sustainability insights from customers, and marketing showcases from the university. All actors benefit from the new green revenue streams generated by Project C.

In conclusion, we found that some actors in the Green FinTech ecosystem are the same as in the general FinTech ecosystem, with additional actors such as associations, universities, and business partners made possible through cross-sectoral financial technology links. All projects emphasize the importance of selecting the right actors to meet customer needs and focusing on their primary business. The key actors vary depending on each project's business model, with customers being crucial for Projects A and C and regulators for Project B. These actors play a significant role in shaping and improving customer experience and engagement. Furthermore, the digitally integrated open innovation ecosystem supports the trend toward cross-industry collaboration, which is essential for generating new green income. This is particularly important for emerging countries like Thailand, where resources are limited, and the cost of energy transition remains high.

Table 4: Pattern of green FinTech NSD process adapted from (Martovoy and Mention, 2016)

Pattern	Description	Sequence of NSD stages	Source
Proactivity-driven	The innovation process is initiated without a specific concern. It allows for the development of new service offerings by taking advantage of alternatives without limitations at the front end. The pattern begins with the idea generation stage	Idea generation → Idea screening → Definition of problems → Business Analysis → Service concept development → Service Design and Testing → Launch	Project B
Strategy-driven	The front end of the innovation process seems to be framed by the scope of the organization's new strategy. The idea generation stage starts after a service concept is first defined	Service concept development → Idea generation → Idea screening → Service Design and Testing → Business Analysis → Launch	Project A, Project C

4.4. Critical key success factors

Compared to De Brentani (1995), the critical success factors identified from the interviews are divided into internal and external factors that align with ecosystem and open innovation concepts (Table 5). However, some factors, such as a structured plan and market knowledge, were not found. This may be because all three projects' service concepts are new and rare in Thailand and due to the uncertain early stages of their innovations. Projects A and C agree that customer demand is the most important external success factor. For Project B, regulation and policy are considered the game-changer success factors. Regarding internal factors, Projects A and C both agree that having a talented young team is crucial for the organization. Additionally, a sense of cooperation is an essential internal factor for all three Green FinTech projects. From observations and transcribed interviews, it is evident that external factors are perceived as more influential than internal factors.

4.5. Drivers and barriers to green FinTech innovation

The key drivers frequently mentioned (Table 6) include unmet customer needs, the pandemic, and the recession. Project B emphasizes that the regulatory framework can be a key driver or barrier at various innovation stages. Project C highlights that the lack of an integrated database is a significant barrier to developing Green FinTech innovation in Thailand. In summary, the economic conditions and the pandemic, which have negatively impacted customer well-being, are major drivers for initiating

Green FinTech in Thailand to address unmet customer needs. Policymakers should promote a transparent sandbox process, facilitate the creation of a green database, and support the infrastructure fund to foster new Green FinTech innovations.

4.6. Guidelines to build a green FinTech innovation

Based on the interview analysis from this research, six guidelines/recommendations can be offered to related stakeholders to stimulate the creation of Green FinTech (Table 7):

- Service concept initiative: The service concept should address real customer pain points, be supported by data-driven evidence, and be co-created with relevant stakeholders. The selected solutions should align with each country's taxonomy for better support.
- Top management support: Support from top management throughout the New Service Development (NSD) process is essential to shorten the innovation timeline.

- Right actor members: Identify and engage the right actors within the ecosystem.
- Suitable technology: Choose suitable and compatible technology that seamlessly links customers with relevant stakeholders while ensuring process and database safety.
- Sandbox criteria for radical innovation: For radical innovations, sandbox criteria should be carefully considered and verified.
- Incubating green talent: Develop and nurture green and young talent and create compensation systems to motivate and encourage them.

Our investigation into the innovation NSD process for Green FinTech ventures has revealed a multifaceted journey marked by distinct stages and influential factors. Through a comparative multi-case study, we identified a common trajectory across the three projects examined, from ideation to implementation (Johnson et al., 2000; Li et al., 2019). Each project showed unique adaptations and strategies tailored to its specific context and objectives, highlighting the dynamic nature of Green FinTech development (Smith, 2006).

Table 5: Critical success factors for green FinTech innovation

Critical success factor	Source
	Internal factors
The climate of cooperation, innovation, and openness Talent team Management support	Project A: "We welcome partners' ideas and service designs. Our EV bike supplier's managing director attends all meetings personally, ensuring quick decisions and actions" Project C: "I believe having a talented team is crucial. Our young team is persistent and explores various approaches to find solutions for launching the project" Project A: "We have a fast track for innovation projects, which helps speed up the entire process significantly"
	External factors
Customer demand Capital Regulation and policy	Project A: "The delivery rider job became very popular during the pandemic, but some young people don't have their own bikes for work" Project C: "We know customers want to reduce their electricity costs, and Thailand is sunny all year round, but solar rooftops are not popular. We need to understand the real needs and pain points" Project B: "I think our country should have an infrastructure fund to support green innovation for young startups" Project B: "We are glad to have passed the sandbox process with the regulator"

Table 6: Drivers and barriers to green FinTech innovation

Driver and barriers	Source
	Drivers
Technology development and digitization Unmet needs Pandemic and social challenge Economic condition Regulatory framework	Project B: "We trust our extensive blockchain experience, so we decided to invest in and develop the energy trading platform with our own funds first, and then proceed to the sandbox process with the regulator" Project B: "The Association estimates upcoming measures for carbon border adjustments on export/import, and there are currently no formal solutions for renewable energy use and carbon offset alternatives" Project A: "During the lockdown, many unemployed individuals from the service industry moved into the delivery rider industry. They need bike rentals rather than long-term financial leases" Project A: "Due to the recession and rising oil prices, we achieved our target in the first month. Riders said our monthly rental fee is cheaper than their previous gasoline and installment fees combined" Project C: "Customers like the idea of co-investing and being prosumers, as it allows them to cut utility costs during the recession" Project B: "With the approval of the renewable energy trading concept, we were able to launch exchanges for Renewable Energy Certificates (REC) and carbon credits in 2022"
	Barriers
Lack of funding Lack of integration ecosystem and database Regulatory framework	Project B: "We invested our own funds because we believe Thailand should have its own technology for a carbon-credit trading system, and we see opportunities in this region. We also think there should be an infrastructure fund to support young startups in green innovation" Project C: "Academic institutions could serve as centers to gather information and cooperation from various parties to facilitate green projects that involve many stakeholders" Project C: "Solar rooftops were not very popular in the past because of unclear regulations on electricity trading"

Several valuable lessons emerged from our critical analysis of key success drivers, barriers, and ecosystem elements. Stakeholder engagement and collaboration were found to be crucial, providing access to resources, expertise, and market insights (Chen et al., 2021). Adaptive strategies and agile frameworks were essential in addressing regulatory challenges and market gaps. Supportive ecosystems, including policy frameworks, financial infrastructure, and industry partnerships, were pivotal enablers of Green FinTech innovation (Kivimäki, 2020; Meng et al., 2021).

These insights culminate in the formulation of guidelines for successful Green FinTech endeavors. Key recommendations include fostering robust stakeholder ecosystems, promoting regulatory

agility, and prioritizing user-centric design and innovation methodologies. By embracing these guidelines, stakeholders can navigate the complexities of Green FinTech innovation more effectively, driving sustainable development and financial inclusion forward. Our study's novelty lies in its comprehensive exploration of the innovation process and success factors specific to Green FinTech, offering actionable insights tailored to the sustainability-driven FinTech sector.

Table 7: Guideline/recommendation to create a green FinTech innovation

Subject	Guidelines/Recommendations
Problem statement	Thematic issues should be included in each country's green taxonomy to facilitate easier funding and support. The needs and pain points of all required stakeholders should be understood deeply, using data-driven evidence
Management support and open working style	Top management should be involved from the early stages, monitor the project until its launch, and promote both internal and external collaboration
Partnership in ecosystem	Focus only on your strong capabilities and find the right partners for other aspects
Financial service/technology selection	Services and technology should not be over-sold but should be suitable and compatible with all stakeholders to ensure the project's long-term sustainability
Regulation	Radical innovations should be checked for approval or meet sandbox model criteria before investment
Talent team	Young talent teams should be incubated and groomed. Special compensation, such as stock options or partial IP ownership for the initiator, should be considered for motivation

5. Conclusion

Based on the qualitative research, the successful implementation of Green FinTech innovation in Thailand follows a strategic-driven pattern for B2C and a proactive-driven pattern for B2B. Seven key actors are crucial for the Green FinTech ecosystem: Startups, Customers, Partners, Associations/Universities, Traditional Financial Institutions, Technology Developers, and Regulators. Effective collaboration among these actors is essential.

Understanding customer behavior beyond pro-environmental actions leads to more successful innovations. Key internal success factors include a talented team, a cooperative atmosphere, and strong management support. However, external factors such as customer demand, capital, and regulation are more influential in achieving success.

The recent recession and pandemic have highlighted unmet needs and problems that Green FinTech can address. To support these potential projects, it is important to prepare regulatory frameworks, transparent database integration, and infrastructure funds.

Key recommendations from the three case studies are:

- Define the right problem: Identify and address the real pain points of customers.
- Develop talented teams: Foster young talent passionate about green business and provide strong management support throughout the project.
- Select compatible technology: Choose appropriate technology and find stakeholders with relevant skills and experience.
- Ensure compliance: Follow related green rules and taxonomy.

Green FinTech solutions are essential connectors that interlink stakeholders and processes. Solving climate-change problems requires collaborative value propositions that exceed individual contributions and necessitate international coordination.

Our findings have implications for stakeholders in various sectors, including financial institutions, policymakers, and technology developers. By following the guidelines proposed in this study, stakeholders can create an ecosystem conducive to Green FinTech innovation, advancing sustainable development and financial inclusion. Additionally, our research highlights the importance of adaptive strategies and collaborative frameworks in overcoming regulatory challenges and market gaps, offering policymakers opportunities to create a supportive environment for Green FinTech ventures. This study contributes to the growing field of green finance and technology, providing practical recommendations to drive innovation and create positive societal impacts.

5.1. Limitation and future research

Due to the limited number of Green FinTech projects in Thailand, some cases in this study included financial services from other areas like energy and mobility. Future research should focus on more direct Green FinTech projects to create clearer guidelines and potentially different results from this study. Additionally, quantitative research on key success factors for creating Green FinTech innovations and on the demand side of decarbonized organization/customer behavior could provide empirical evidence for a deeper understanding.

Compliance with ethical standards

Ethical considerations

This study was conducted in accordance with ethical standards. Informed consent was obtained from all participants prior to their involvement in the research. Participants were assured of their anonymity and confidentiality, with all data being stored securely and used solely for academic purposes. Ethical approval for this study was

obtained from the Chulalongkorn University Institutional Review Board.

Conflict of interest

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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