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Smart digital platforms for carbon neutral management and services: Business models based on ITU standards for green digital transformation

Han-Teng Liao[1,2,3]*, Chung-Lien Pan[1,2,3,4]* and Yuan Zhang[1,4]

[1]Laboratory of ESG Data-Driven Decisions, Nanfang College-Guangzhou, Conghua, Guangzhou, China, [2]Higher Education Impact Assessment Center, Nanfang College-Guangzhou, Conghua, Guangzhou, China, [3]Oxford Roadmapping, Guangzhou, Guangdong, China, [4]School of Accounting, Nanfang College-Guangzhou, Conghua, Guangzhou, China

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EDITED BY
IMR Fattah,
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Cong Luo,
Hohai University,
China

*CORRESPONDENCE
Han-Teng Liao
✉ h.liao@ieee.org
Chung-Lien Pan
✉ panzhl@nfu.edu.cn

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This brief research report focuses on the effects of artificial intelligence (AI) on the environment, by analyzing the latest documents issued by major standard organizations such as the International Telecommunication Union (ITU) and the Internet Society of China (ISC). By outlining the latest developments into a platform canvas for carbon neutrality management and services, this report identifies the potential of "AI *of* the environment" (i.e., the material composition and environmental impact of AI itself) and "AI *for* the environment" (i.e., the purposeful use of smart applications to benefit the environment). The role of AI is contextualized in the digital platform design for the provision of services on carbon emission data, which serves as the material foundation for smart services facing both the producers and the consumers of such information. Contributing to the design of business models that enable open innovations, this report discusses the emission impact reduction mechanisms that can optimize, substitute, induce, manage, and facilitate processes and services, indicating the potential of AI-enabled smart services such as forecasting, planning, and recommendation systems. Despite the limited disciplinary considerations and detailed discussions on specific AI technologies, this report provides a simple, practical, and flexible technology roadmap that can be used as a guide for researchers and practitioners to refine their operations and designs and to follow best practices. This report succinctly visualizes key elements of digital platforms *of*/*for* GHG emission reduction and their enabling mechanisms, serving as an AI technology roadmap for future research and innovation in the field.

KEYWORDS

digital economy, carbon neutrality, AI for good, information systems, systems innovation, socio-technical transition, digital platform, open collaboration

1. Introduction

International organizations such as the International Telecommunication Union (ITU), have been focusing on the application of Information Communication Technologies (ICTs) to "build back greener" after COVID-19, leading to new standards for green digital transformation (ITU, 2020; Johnson, 2022). Global and European research initiatives, such as Destination Earth of the

Global Earth Observation System of Systems (GEOSS), are working on building a digital ecosystem including a "datafication" paradigm, aiming to generate actionable intelligence from footprint data for smart service provision, as proposed by the Big Data Lead Scientist of the European Commission Joint Research Center (Nativi et al., 2021).

These two developments, the one from the ICT sector and the other from ecology science, exemplify the two ways in which artificial intelligence (AI) affects the environment: AI *of* the environment and AI *for* the environment. AI *of* the environment refers to the material composition and, thus, environmental impact of AI itself. AI *for* the environment indicates the purposeful use of smart applications to benefit the environment, including monitoring, predicting, and mitigating the impacts of climate change and other environmental challenges. Therefore, to maximize the positive impact of AI on the environment, it is important to consider both the environmental benefits and the costs of AI technologies. At the intersection of the two developments is the "datafication" that enables smart and sustainable services on carbon emissions or greenhouse gas emissions (GHGs), data. For instance, AI algorithms can optimize data centers' energy consumption (Sirojan et al., 2022).

1.1. The central role of digital platforms in implementing and advancing AI applications

Digital platforms are essential to create data-driven AI applications that shape the market, human behavior, and regulations. A study in Europe looked at how digital energy platforms can help both consumers and businesses and support the European Union's (EU) climate and digital transformation goals (Duch-Brown and Rossetti, 2020). Platforms facilitate interactions between users and stakeholders and, thus, produce value intelligence on such interactions (Nativi et al., 2021). A study argued that to solve green technology development issues, platform-based services need to address issues such as digital innovation, power structure, and government intervention (Reza-Gharehbagh et al., 2022b).

Digital platforms for carbon neutrality are expected to provide intelligent services. In December 2022, the Internet Society of China (ISC) released a request for comments on the document "Carbon Peak Carbon Neutral Management and Service Platform (CPCNMSP)," which may offer opportunities to use digital footprint data to provide smart services that drive sustainability, as defined by previous research (Nativi et al., 2021). Innovation can be advanced by combining AI and social science (Cai et al., 2019), allowing organizations such as governments and companies to be held accountable for reducing their carbon emissions. Sustainability reporting activities also often involve environmental, social, and governance (ESG) factors, emphasizing the importance of carbon and ESG data in making data-driven decisions for green and digital transformation (Liao et al., 2021).

1.2. The critical role of business models in building carbon management platforms

Thus, building business models for carbon neutrality platforms becomes critical. The achievement of carbon neutrality requires multidisciplinary collaboration to advance policies, business models, behavior changes, etc. (Macknick, 2011; Zhang et al., 2021). These play a crucial role in leveraging information and intelligence in carbon accounting and carbon markets, as supported by a conceptual paper titled "Carbon as a Metric of the Human" (Whitington, 2016). They also provide informational spaces as the material infrastructures for carbon accounting and carbon markets, as argued by an analysis of two Beijing-based enterprises working to decarbonize China. Business models are instrumental in advancing sustainable supply chain finance digital platforms (Reza-Gharehbagh et al., 2022a). Nonetheless, little research has been conducted on carbon neutrality platforms.

The aim of this study was to design a generic platform business model to simplify the collaboration and innovation around emission data. Inspired by business model research for climate services (Larosa and Mysiak, 2020), the proposed platform business model for emission data management and services emphasizes the use of canvas as a data collection and analysis framework. In addition, its mixed-method analysis shows the value of a co-creation approach to innovate with digital platforms by building value networks through collaboration. Here, the concept of "open collaboration" means the use of open platforms to promote the principles of egalitarianism, meritocracy, and self-organization (Riehle et al., 2009). This idea has inspired the notion of open innovation for market and social entrepreneurship (Dieguez et al., 2020; Gay, 2020; Temiz and Broo, 2020). These phenomena are enabled by digital technologies, such as internet platforms, and are transforming human societies (Parker et al., 2016). Hence, the development of carbon neutrality platform business models requires collaboration and innovation in the use of emission data for AI-enabled intelligent services.

2. Methods

This study applied the design science framework (Eisape, 2022). Originating from design science and employed in information technology and system research (March and Smith, 1995; Hevner et al., 2004), this framework is articulated along four research activities: build and to evaluate from design science, and theorize and justify from natural and social science. Previous experimental research on AI-enabled smart platforms (Brecht et al., 2021) and a case study on a German standard-setting organization (Eisape, 2022), demonstrated the usefulness and validity of this framework.

Focusing on the two research activities of this framework (i.e., to build and evaluate), this study followed a two-step process. First, it examined the relationship between ICT and the environment through a selected survey of technical documents on the role of the ICT sector in GHG emissions reduction for itself and other sectors. Second, focusing on value-creation statements and overall logic, it mapped the technical, environmental, and business statements retrieved to the overall platform business model canvas developed by Choudary (2015) and Parker et al. (2016).

In relation to the use and application of the platform business model, various canvases were proposed and applied for research and practice (Choudary, 2015; Allweins et al., 2021; Bätz and Siegfried, 2022; Eisape, 2022; Şimşek et al., 2022). The differences among these variants are subtle, as expected from academic and professional efforts to apply the canvas to design, build, and evaluate digital platform-based business models. The wide application of the platform canvas testifies to the usefulness of design science in information systems, information technology, and ICT. Also, adopting the latest developments in the digitalization of roadmapping workshops (de Oliveira et al., 2022), two design workshops were executed by the authors using the online tool Miro.

The selection of the ITU and Chinese technical documents is justified by their organizational influence and knowledge in the ICT sector for climate actions and their relevance to the topic. First, two standardization documents by the ITU, widely publicized at the COP27 in November 2022 (Johnson, 2022), were identified as providing the latest international and industrial science-based knowledge in the field. Second, both architectural and functional requirements of China's "CPCNMSP" were taken from the most recent "Request for Comments" by the Internet Society of China (2022) and analyzed to collect the technical, business, and regulatory needs in the use of emission information. Finally, both the ground truths and value statements were synthesized into the platform canvas, formulating critical questions to encapsulate the retrieved requirements and value statements. These questions served as working questions to contribute to a form of technology roadmapping (Daim et al., 2019; Phaal, 2019) for both AI *of* and *for* the environment in carbon neutral management and services.

3. Results

This study found that ITU green digital transformation standards for provide the requirements, assessment, and implementation of AI *of/for* the environment, whereas China's CPCNMSP outlines the technical and service requirements lack AI *of* the environment. This study proposed a platform canvas, shown in Figure 1, which synthesizes the selected content of these documents, featuring questions to design AI-enabled smart services *of/for* the environment.

3.1. A selected survey of the ITU standards for green digital transformation

The ITU Standards for Green Digital Transformation consist of two standards developed by the ITU-T Focus Group on "Environmental Efficiency for Artificial Intelligence and other Emerging Technologies" (FG-AI4EE). It is divided into three Working Groups:

- Working Group 1 (WG1): defines the concepts and standardization requirements for deploying AI, blockchain, 5G, and other emerging technologies efficiently and sustainably, with additional consideration of their benefits in advancing the United Nations Sustainable Development Goals (UN-SDGs; FG-AI4EE, 2022a).
- Working Group 2 (WG2): develops the assessment and measurement tools in order to evaluate the environmental performance, energy efficiency, and eco-friendliness of technologies, such as KPIs, metrics, scorecards, impact matrix, etc. (FG-AI4EE, 2022b).
- Working Group 3 (WG3): describes the methodologies to implement technologies, including guidelines on solutions, use cases, and best practices (FG-AI4EE, 2022c).

Based on the tasks of these Working Groups, this study examined the AI-environment relationship. Focusing on AI *of* the environment, WG1 provides the definitions for the deployment of requirements for

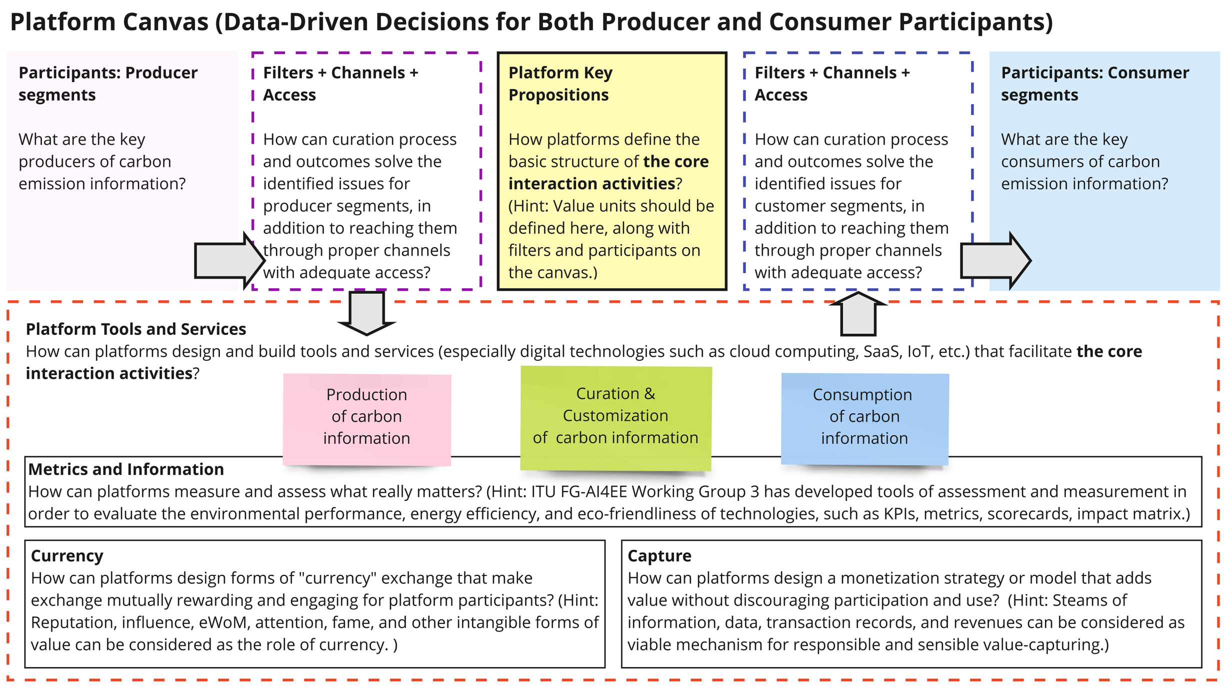

FIGURE 1
Platform canvas adopted and deployed for this research.

AI, blockchain, 5G, and other emerging technologies. Note that the expression "emerging technologies" can be roughly understood as digital or ICT technologies, because of the ITU mandate. WG1's AI *for* the environment consists mainly in the advancement of UNSDGs. WG2 develops the assessment tools, and WG3 implements solutions *for* the environment.

3.1.1. Specifying the ICT environmental impact assessment methods

The ITU-T L.1470 standard (ITU-T, 2020) outlines how the ICT sector can support the Paris Agreement by accounting emissions along the ICT value chain, from electricity to end-users.

Since both digital platforms and AI belong to the ICT sector, ITU-T L.1470 outlines how the ICT sector's GHG emissions trajectories can be compatible with the UNFCCC Paris Agreement, thereby laying the groundwork for accounting the ICT *of* the environment. To ensure that the ICT contribution trajectory is in line with climate change scenarios, such as the 1.5°C scenario of the Science-based Targets (SBT) initiative, the ICT possibilities were explored and examined along two perspectives, namely including and excluding electricity supply chain and grid losses (more details are provided in Supplementary material 1.1). Five ICT sub-sectors, i.e., mobile networks, fixed networks, data centers, user equipment, and enterprise networks, were also examined to identify opportunities and risks.

The complexity of the scope of GHG emissions was assessed, as it was instructive for the research on AI *of* environment. As illustrated in Figure 2, a company's emission in a value chain can be classified into three categories: Scope 1, which covers the direct emissions of its operations and assets; Scope 2, which covers its purchased energy; and Scope 3, which covers supply chain emissions. More in detail, Figure 2 illustrates the roles of ICT companies as operators and manufacturers along the ICT value chain, highlighting their influence both upstream (to the suppliers of equipment and electricity) and downstream (to the end-users). Indeed, covering subsectors such as data centers, enterprise networks, and user equipment, the document accounted for overhead and embedded emissions.

Appendix II includes the following statement on the opportunities of the ICT sector to help decarbonize other sectors:

> On the one hand, ICTs have an environmental impact at each stage of their life cycle, from energy and natural resource consumption to e-waste. On the other, ICTs can enable vast efficiencies in lifestyle and in all sectors of the economy through the provision of digital solutions that can improve energy efficiency, inventory management, and business efficiency by reducing travel and transportation, e.g., teleworking and videoconferencing and by substituting physical products for digital information. The latter capacity is referred to collectively as second-order or enablement effects.

3.1.2. Describing the ICT solutions for the impact assessment of GHG emissions

The ITU-T L.1480 standard (ITU-T, 2022) focuses on the impact assessment of the use of ICT solutions for other sectors and GHG emissions.

Since both digital platforms and AI can other sectors, this standard describes the GHG emissions reduction mechanisms for various sectors using a structured method. Titled "Enabling the Net Zero transition," it documents assessment principles and methods to guide the use of ICT solutions to improve the consistency, transparency, and comprehensiveness of the assessments of the impact of GHG emissions (more details are provided in Supplementary material 1.2).

Useful specifically for AI *for* environment, this standard provides guidance on the downstream effects on the GHG emissions of other sectors, i.e., the "net second order effect and higher order effects." It describes enabling mechanisms for GHG emissions reduction through optimization, substitution, induced consumption, information management, and facilitation services of sectors such as energy, manufacturing, building, transportation, agriculture, and forestry. It also contains several annexes, including a list of potential ICT solutions, usage scenarios building, methodologies, an effect checklist, and a guidance for the GHG impact assessment of ICT-generated financial effects. As a toolbox to assess the GHG impact of ICT solutions for specific customers in an actual scenario, it also summarizes six main normative principles: relevance, completeness, consistency, accuracy, transparency, and conservativeness, which serve as the necessary foundations for preventing greenwashing

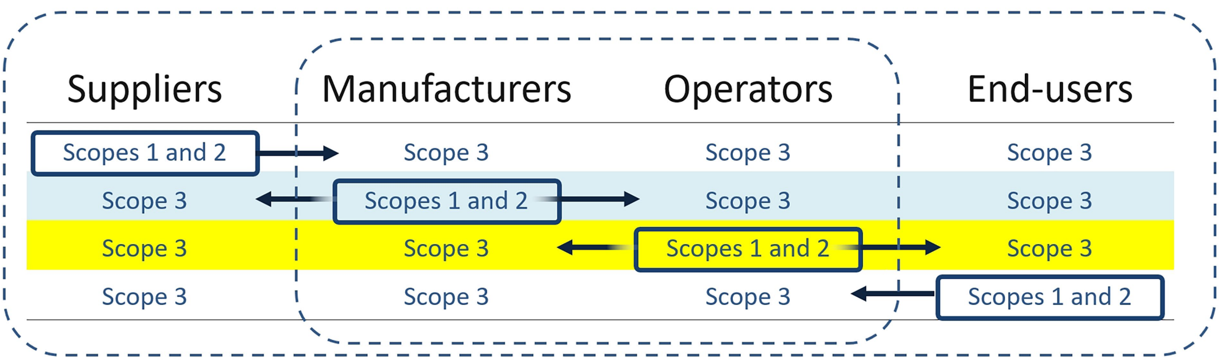

FIGURE 2
Accounting for the Scopes 1 and 2 of GHG emissions from the perspectives of suppliers, manufacturers, operators and end-users, and for the Scope 3 of other subjects in the supply chain. Adapted from Figure 1 of the ITU standard (ITU-T, 2020).

TABLE 1 Architectural requirements of China's "Carbon Peak Carbon Neutral Management and Service Platform."

Requirements	Original section numbers and Chinese title	Main implementation formats or components
Display and curation layer	4.8 展示层	Wide-screen dashboard display, interactive display, PC terminals, mobile devices, etc.
Application layer	4.7 应用层	Two sides: (1) facing the side of government bodies and (industrial) parks and (2) facing the side of enterprises
Algorithm model layer	4.6 算法模型层	Algorithm models include but are not limited to: industrial/sectoral GHG emission accounting models, provincial GHG inventories compilation accounting models, national certified voluntary GHG reduction method models, carbon quota estimation models, and product carbon footprint measurement models.
Data management layer	4.5 数据管理层	The following databases, to provide functions such as high-quality data resource management, storage, statistics, and exchange, should be built: foundation databases, data collection databases, business databases, statistical databases, etc.
Technology support layer	4.4 技术支撑层	Digital technologies include but are not limited to: (a) big data, (b) cloud computing, (c) blockchains, (d) digital twins, (e) mobile communications such as 4G, 5G, LoRa, etc. These digital technologies should ensure the integrity and authenticity of electronic data, to achieve services for data relations, two-way traceability, sharing, etc.
Infrastructure layer	4.3 基础设施层	Components include computing devices, storage devices, and network environments, mainly used to support data processing and exchange at the technology support layer, data management layer, and algorithm model layer.
Data collection layer	4.2 数据采集层	Data collection methods include but are not limited to: (a) manual data entry, (b) Internet of Things, and (c) physical/smoke measurement. The objects of measurement should follow the related standards GB/T 32150–2015, GB/T32151, Guidelines for Provincial Greenhouse Gas Inventories, ISO 14067:2018, etc.

Note. English translation is provided by the authors for the purpose of the research, and it does not represent the official translation of the original drafters.

(Liang et al., 2020; Yu et al., 2020; Montero-Navarro et al., 2021; Lee, 2022) by maintaining a "frame" for conscious AI development "for good" (Cukier et al., 2021).

3.2. China's carbon peak carbon neutral management and service platform

The CPCNMSP document outlined the first Association Standard draft for the development of ICT solution standards for carbon neutrality management and services. It was issued on December 9, 2022, with a deadline on January 8, 2023 for the first iteration of comments (Internet Society of China, 2022). The main content of this document is summarized in Tables 1, 2.

3.2.1. Architectural requirements

Table 1 summarizes the architectural requirements, as articulated in seven layers: data collection, infrastructure, technology support, data management, algorithm model, application, display, and curation layers. The main takeaways for smart ICT solutions for carbon neutrality are as follows:

- The algorithm model layer is crucial for machine learning and artificial innovations, between the upper two layers (i.e., application and "display and curation" layers), and several technological layers below.
- The application layer fits the definition of platform economy as a multi-sided market. It serves both the public and private sector on two sides: (1) government bodies and (industrial) parks, and (2) enterprises. As a matter of fact, in China major industrial or scientific parks are often owned and managed by local or ministerial authorities.
- The overall model follows conventional data science and analytics processes or life cycles: problem definition, data mining, data preparation, exploratory data analysis, feature engineering, model building, and model evaluation. In particular, the ICT and digital technologies such as big data, cloud computing, blockchains, digital twins, and mobile communications such as 4G, 5G, and LoRa are explicitly described in the technology support layer, with the stated goal to "ensure the integrity and authenticity of electronic data, to achieve services for the data relations, two-way traceability, sharing, etc."

However, the CPCNMSP lacks the consideration of the environmental impact of ICT devices and related solutions.

3.2.2. Functional requirements

Table 2 summarizes the detailed functional requirements of the CPCNMSP, highlighting how the need for carbon accounting for the two-sided market participants is supported by data science processes. Several observations were made in this study:

- As shown in the first three rows of Table 2, for both sides alike, the requirements include carbon emission accounting, curation, and analytics. These functions require related data processes and outcomes to follow relevant national and international standards, as well as the needs of two-sided market participants, including specific analysis such as decarbonization analysis, emission-level benchmarking evaluation, and diagnosis.

TABLE 2 Functional requirements of China's "Carbon Peak Carbon Neutral Management and Service Platform."

Requirements	5.1 Facing the side of government bodies and (Industrial) parks	5.2 Facing the side of enterprises
5.1.1 & 5.2.1 Carbon emission accounting	Functions include emission-related data entry, import, anomaly warning, accounting, report generation, etc. The platform's accounting function should support and follow standards such as GB/T 32150–2015, GB/T32151, and the Guidelines for Provincial Greenhouse Gas Inventories	Functions include emission-related data entry, import, anomaly warning, accounting, report generation, etc. The platform's accounting function should support and follow standards such as GB/T 32150–2015, and GB/T32151.
5.1.2 & 5.2.2 Carbon emission curation	Functions are applying various visualization and other display formats to curate the statistics, ranking, and dashboards of the carbon emissions and energy consumption status of a region	Functions are applying various visualization and other display formats to curate the statistics, ranking, and dashboards of carbon emission, energy consumption, and carbon assets status of an enterprise and its affiliate or subsidiary companies
5.1.3 & 5.2.3 Carbon emission analytics	Functions consist of the decarbonization analysis, benchmarking evaluation, etc. for a region	Functions consist of the evaluation, analysis, and diagnosis of the emission levels, etc. for an enterprise and its affiliate or subsidiary companies.
5.1.4 Carbon emission peak prediction	Functions consist of the prediction, factorial analysis, recommendations-generation, etc. for the carbon emission peaking of a region	
5.2.5 Carbon emission planning		Functions consist of the prediction, factorial analysis, measurement, recommendations generation, etc. for carbon emission peaking of an enterprise and its affiliate or subsidiary companies
5.1.5 Carbon goal assessment management	Functions consist of goal assessment management, outcomes comparison, etc.	
5.2.4 Product carbon footprint tracking		Functions mainly include product-related emission data entry, import, accounting, statistics, analysis, benchmarking, ranking, etc. The platform's accounting function should support and follow carbon footprint standards for products such as ISO 14067:2018
5.1.6 Carbon project management	Functions include the management of national certified resource carbon emission reduction projects, carbon sink projects, high-energy-consumption and high-emission projects, etc.	
5.2.7 Carbon-reduction project management		Functions include the management of the report query, flow control, monitoring, analysis, warning, etc. for the carbon emission projects and carbon sink projects of an enterprise and its affiliate or subsidiary companies
5.2.6 Carbon-reduction performance management		Functions include the internal performance on carbon-reduction assessment management, outcomes evaluation, etc. of an enterprise and its affiliate or subsidiary companies
5.1.7 Carbon emission organizations' file archive	Functions mainly consist of organization manifest record maintenance, data overview, monitoring, warning, etc.	
5.2.8 Carbon asset management		Functions include the measurements, statistics, analysis, management, etc. of the carbon assets of an enterprise and its affiliate or subsidiary companies
5.1.8 Carbon information announcement	Functions include the management of information announcements within the platform	
5.2.9 Carbon information disclosure		Platforms should support the relevant information disclosure to the public regarding the carbon emissions of an enterprise and its affiliate or subsidiary companies. Disclosed information should include, but not be limited to, the basic information, annual total carbon emission, annual total carbon emission reduction, carbon emission targets, carbon emission reduction action, etc.

Note. The content of each item was reorganized and re-aligned for the purposes of this research, while the section numbering remained consistent with the original document to ensure accurate reference.

- As shown in the fourth and fifth rows, the functions regarding prediction and planning imply the long- to short-time-frame prediction capabilities to be supported by algorithms and AI.
- As shown in the rows from sixth to tenth, the functions regarding carbon assessment, product carbon footprint tracking, and other higher-level functions for project management support, suggest the daily data managerial efforts that may require machine assistance to provide anomaly warning and prevent human errors.
- As shown in the last four rows, functions regarding information record-keeping, archive, exchange, and disclosure aim to provide the systematic foundation to organize, manage, and curate the information flow, which can also benefit from AI-enabled automation, smart assistants, and smart integrity-audits.

3.3. Platform canvas

This subsection describes the key results from the building and evaluation of carbon neutrality platforms. Additional references will be provided as theoretical justifications, following the aforementioned design science framework (March and Smith, 1995; Hevner et al., 2004; Eisape, 2022). Since it is beyond the scope of this study to provide a comprehensive review or justification, a more detailed description of the design-thinking process and outcomes is provided in Supplementary material 1.3. This subsection highlights only the key findings for carbon neutrality platforms, whose critical design questions are illustrated in Figure 1.

3.3.1. Recognizing the environmental impacts of digital platforms: Platforms *of* the environment

Starting from carbon emission information, the canvas asks the following design questions in the following key design building-block areas:

- Metrics and information (inside the "Platform Tools and Services" at the center of Figure 1): How can platforms measure and assess what really matters?
- Producer and consumer participants (at the top-left and top-right of Figure 1): What are the key producers and consumers of carbon emission information?

To answer the first question, digital platforms must consider their own environmental impact, as discussed earlier in the highlights of the ITU standards. The life cycle of running the platforms, from energy consumption to e-waste, should be part of the metrics. Digital platforms themselves must become carbon neutral, following the ITU-T L.1470 and L.1480 standards. Researchers, policymakers, and professionals can ITU FG-AI4EE WG3 documents for more details. As this is missing from the CPCNMSP document, its timely inclusion is advised.

3.3.2. Designing smart management and services: Platforms *for* the environment

To answer the second question, related to the participants at the top two corners of the canvas, the CPCNMSP document identified two categories of organizations in China: the public and the private sector. While the initial version focused on the technical support for carbon emission information service and management, the canvas of Figure 1 fills the main gap in value propositions, i.e., the central element of platform business model design.

Entering the important topic of the interactions in the use of carbon emission information, the canvas asks the following design questions to ensure the platforms-*for*-the-environment purpose:

- Platform key propositions (at the top-center of Figure 1): How can platforms define the basic structure of the core interaction activities?
- Platform tools and services (at the center of Figure 1): How can platforms design and build tools that facilitate the core interaction activities?

To address these design questions, the ITU-T L.1470 and L.1480 documents offer economic and business best practices, while the CPCNMSP outlines functional specifications for carbon accounting and carbon market processes (see Section 3.2.2). Here, AI-enabled application opportunities can be designed through the ITU enabling mechanisms of optimization, substitution, induced consumption, information management, and facilitation services. Specific examples include AI-assisted decarbonization analysis, benchmarking evaluation, prediction, and planning, carbon footprint tracking, energy management, emission forecasting, supply chain analysis, emission reduction recommendations, and automated data collection.

3.3.3. Building smart management and services: Platforms *for* the environment

As indicated by the four arrows in the canvas, to put platforms in operation it is necessary to address the actual design of production, curation, and consumption of carbon information, as shown by the three colored boxes at the center of Figure 1, which can be generated from the platforms and then, simultaneously, pulled from the targeted producer participants and pushed toward the targeted consumer participants. These push and pull processes will require the use of filters, channels, access, or any combination of the three, thereby raising the following design question on curation:

- Filters + Channels + Access (at the top of Figure 1): How can the curation process and outcomes solve the problems faced by producer and consumer participants?

The purpose of the platforms *for* the environment must be achieved through the meaningful interactions of participant producers and consumers on the use of carbon information. To this respect, the previously discussed ITU enabling mechanisms for different sectors can be helpful. Also, the CPCNMSP document's top layer of "display and curation" can be improved by the user-centered design thinking principles embedded in the canvas. AI-assisted digital analytics and marketing services are expected to be helpful in this regard.

3.3.4. Evaluating business model innovations and impacts: Platforms *of/for* the environment

What remains to be done to make platforms economically viable, as illustrated by the "currency" and "capture" boxes at the bottom of Figure 1, with the following design questions:

- How can platforms design forms of “currency” exchange?
- How can platforms design a monetization strategy or model that adds value without discouraging platform participation and use?

The canvas suggests adding two blocks, i.e., currency and capture, to China’s CPCNNSP proposal, to ensure alignment with ITU-T L.1470 and ITU-T L.1480 standards, by emphasizing the need to articulate value-defining and -capturing activities for green digital transformation.

Focusing on the notion of platforms *of* and *for* the environment in values, based on previous research on green marketing (Chan et al., 2012; Dangelico and Vocalelli, 2017; Liao and Huang, 2021; Liao and Pan, 2021; Liu and Liao, 2021), this study suggests to consider reputation, influence, electronic word-of-mouth (eWoM), fame, and other intangible forms of value. To capture values from the streams of information, data, transaction records, and revenues, platform business models to design minimum viable ecosystems (Lewrick et al., 2018) should be considered. AI-assisted digital marketing, especially for industrial marketing in the supply chain, will play a crucial role in defining and capturing values that include the environment.

4. Discussion

The platform canvas proposed in this study summarizes the design of a digital platform to manage and provide services on carbon emission data, as the material foundation for smart services facing both producers and consumers of carbon information. This study provided a succinct summary and iteration of digital platform design for smart management and services on carbon emission data.

4.1. Designing business models that enable open innovations

The main contribution is the business model design innovations that optimize the positive impacts of digital platforms, as outlined in the latest ITU and ISC documents:

- The GHG impact reduction mechanisms can optimize, substitute, and induce consumption through the use of AI such as recommendation systems and cognitive technologies. These technologies can enhance smart services, especially at the filters, channels, or access points interfacing with producer and consumer participants on the canvas.
- The GHG impact reduction mechanisms can manage and facilitate information services *via* the application of smart services and machine learning modeling, especially at the core block of platform tools and services.
- The abovementioned ICT and AI *for* the environment mechanisms need to run on the ICT *of* the environment, which can also benefit from the development of the AI *of* the environment when considering the AI use life cycles and footprints.

4.2. Articulating value propositions of AI *of* and *for* the environment

The second contribution of this study is the articulation of value propositions of AI *of* /*for* the environment, in the context of digital platforms of carbon emission information services. This study recognizes the values behind technical work details (e.g., enabling mechanisms, assessment methods, and design requirements) done by influential organizations such as the ITU and ISC, and highlights the importance of such international public goods. Through proposed platform canvas design questions, this study summarized the value propositions of digital platforms *of*/*for* the environment.

The environmental impact of running smart digital platforms, including e-waste, software, and hardware life cycles, energy, and natural resource consumption, should be scientifically assessed according to the ITU document to ensure AI *of* the environment. The positive impact of such smart solutions should also be encouraged, as innovations that bring efficiencies in lifestyle, behavior, and operations change through AI-enabled mechanisms. The proposed canvas and the questions help researchers and professionals to initiate such discussions.

4.3. Limitations and future research directions

The authors acknowledge that this brief research report has limitations, such as limited disciplinary considerations, lack of discussions of specific AI technologies, and lack of a comprehensive review of all relevant literature. Also, platform canvases, as the one proposed in this study, often lack technical and economic details. In addition, future research should further justify, validate, and verify the design outcomes, as demonstrated by AI-enabled smart platform experiment research (Brecht et al., 2021). Nevertheless, this brief report provides a simple, practical, and flexible technology roadmap that can be used as a guide for researchers and practitioners to refine their operations and design, using the critical questions provided, to follow best practices, and to innovate ICT- and AI-enabled solutions on digital platforms. This report succinctly visualized key elements of digital platforms *of*/*for* GHG emission reduction and their enabling mechanisms, serving as an AI technology roadmap for future research and innovation in the field.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary material, further inquiries can be directed to the corresponding authors.

Author contributions

H-TL and C-LP contributed to the conception and design of the study. H-TL collected and organized the document database. C-LP, H-TL, and YZ conducted the platform canvas workshop. H-TL wrote the first draft of the manuscript. YZ executed the project administration and funding acquisition. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fevo.2023.1134381/full#supplementary-material

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