6G Sustainability: Prospective Business Models[1]

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ABSTRACT

This paper explores how 6G can become a transformative enabler of sustainability by embedding environmental, societal, and economic considerations into its design and business models. Drawing on insights gained from recent work across several research and innovation initiatives and projects, we argue that a purely technology-driven approach is insufficient for widespread social acceptance and lasting impact. Instead, we propose a paradigm shift toward value-based outcomes, multi-stakeholder ecosystems, and cross-sector innovation. The paper outlines new sustainability-oriented business models from circular economy marketplaces to regenerative partnerships and digital inclusion services that reframe connectivity as a platform for shared value. Emphasis is placed on measurable outcomes, such as carbon reduction and social equity, facilitated by 6G's advanced capabilities in sensing, data processing, and low-latency communication. We highlight that, for instance, piloting modular platform architectures, developing outcome-based monetization models, and nurturing early-stage developer ecosystems will ground this vision. The study concludes with actionable steps and recommendations to support this transition, highlighting the critical role of collaborative ecosystems and evidence-based metrics in shaping a trusted, inclusive, and sustainable 6G future.

KEYWORDS

6G, Sustainability, Business models, Circular economy, Digital inclusion, Value-based innovation, Cross-sector collaboration

1 Introduction

The telecommunications industry stands at a critical juncture as it prepares for the sixth generation (6G) of wireless networks, expected to emerge by 2030. Within the context of next generation networks and services development, we have had the opportunity to investigate and analyze several challenges and opportunities that can lead to innovative business model perspectives. Unlike previous generations that primarily focused on technical performance metrics, 6G presents an unprecedented opportunity to fundamentally reimagine how telecommunications infrastructure can serve broader societal needs while maintaining economic viability.

The transition from 5G to 6G represents more than an incremental technological advancement; it embodies a paradigmatic shift toward sustainable and socially responsible innovation. The traditional approach of deploying telecommunications technology first and addressing societal implications later is no longer sufficient in an era where stakeholders demand transparency, accountability, and measurable positive impact from technological investments.

6G4Society is an ongoing Smart Networks and Services Joint Undertaking (SNS JU) project that supports and promotes the integration of societal, environmental, and economic values in 6G, ensuring its design, development, and adoption contribute to a sustainable future while fostering social acceptance. This initiative represents a collaborative effort to position 6G not merely as a technological upgrade, but as a catalyst for addressing pressing global challenges including climate change and digital inequality, and supporting sustainable development goals.

When aiming to develop 6G as a technology that integrates societal, environmental, and economic factors by design, it becomes clear that a purely technology-driven approach is insufficient to serve the purpose and may even raise social acceptance concerns and issues. Previous network generations have sometimes encountered resistance due to concerns about privacy, environmental impact, and digital inequalities, underscoring the importance of adopting a holistic approach that considers broader stakeholder needs from the earliest stages of development.

This involves considering several critical aspects from the outset:

- **Moving beyond technical metrics to value-based outcomes**: Traditional business models in telecommunications (and several other Information and Communication Technology (ICT) sectors) are built on metrics like data volume and speed. A sustainable 6G requires moving towards value-based models that monetize measurable positive outcomes. This means that success is defined not only by network performance, but also by its contribution to CO_2 reduction, enhanced energy efficiency,

[1] The latest full version of this paper is available at ACM library, DOI 10.1145/3748699.3749820 .

improved public health, or greater digital equity. This implies that business models must be designed to capture and share the value created from these tangible environmental and social benefits.

- **Embracing multi-stakeholder ecosystems**: The development of sustainable 6G cannot happen in a silo. It calls for strong collaboration between a diverse range of stakeholders, including network operators, technology providers, governments, regulators, vertical industries (such as energy, agriculture, and healthcare), NGOs, and citizens.[2] New business models must be structured as multi-sided platforms that create and distribute value across this ecosystem, aligning incentives and fostering public-private-people partnerships.
- **Designing for social acceptance and trust**: For 6G to succeed, it must be trusted by the people it serves. This goes beyond simply avoiding public backlash. It means proactively designing business models that embed principles of privacy, security, transparency, and digital inclusion. Models should prioritize equitable access, bridge digital divides through inclusive pricing and community-centric platforms, and empower citizens, ensuring that the technology genuinely enhances well-being and is perceived as a force for good.[3]
- **Fostering cross-sector innovation**: The greatest opportunities for sustainable 6G business models lie at the intersection of connectivity and other industries, such as, for example, transport, mobility, logistics, forestry, agriculture, etc.[4] We thus argue that 6G should be viewed as an enabling platform that can transform other sectors, including vertical sectors. This requires business models that are flexible, open, and built on standardized Application Programming Interface (APIs), allowing developers and innovators from any field to build sustainability-focused applications and services, from circular economy marketplaces to smart grid orchestration platforms.

This paper explores the theoretical foundations and practical implications of this paradigm shift, examining how emerging business model frameworks can be adapted to support 6G sustainability requirements. Through analysis of current trends and innovative approaches being developed within the 6G4Society project, we provide actionable insights for industry leaders, policymakers, and researchers working to shape the future of telecommunications in service of both business objectives and the broader public good.

We proceed as follows: in Sections 2, 3, and 4, we analyze, respectively, the environmental, societal, and economic sustainability business models in the context of 6G. In Section 5, we delve into scenarios across critical themes of a sustainable 6G development: user experience, business sustainability, and geopolitics, analyzed through economic, societal, and environmental lenses. This comprehensive perspective enables business models that simultaneously address all three sustainability dimensions (as said, presented in Sections 2-4). In Section 6, we consider the stakes, challenges, and opportunities for transforming the current concerns, e.g. privacy concerns regarding data, into a tool for positive socio-economic and environmental change. Section 7 concludes our article.

2 Environmental Sustainability Business Models

The Integration of Circular Economy Considerations

The foundation of sustainable 6G relies on three key dimensions: advanced observability, circular economy principles, and empowered choice. These collectively guide industry actions toward creating a truly sustainable 6G ecosystem. This framework enables revolutionary business models centered on resource optimization, waste reduction, and comprehensive lifecycle management that were previously impossible with earlier network generations.

Green-as-a-Service Models

The environmental sustainability paradigm paves the solid groundwork for several new service categories:

(i) Carbon Intelligence Services:

- Real-time carbon footprint monitoring services leveraging 6G's ultra-dense sensor networks and AI capabilities to provide granular environmental impact live tracking across entire supply chains. For instance, Siemens' SiGREEN enables real-time tracking of product-level carbon emissions across supply chains using decentralized data sources and blockchain.[5] These services empower organizations to detect inefficiencies, ensure compliance, and take immediate action to reduce emissions at every operational touchpoint.[6] In a 6G-enabled future, as an example, a global apparel manufacturer can deploy these services across its value chain, from cotton farms and textile mills to distribution centers, using embedded IoT sensors and AI analytics as depicted in Figure 1 below. The platform continuously measures carbon footprint in real time, detects anomalies such as excessive energy usage or high-emission logistics routes, and suggests optimizations like rerouting shipments or switching to renewable energy suppliers.

[2] European Commission, Directorate-General for Communications Networks, Content and Technology. 2021. *A European vision for the 6G network ecosystem*. Publications Office.
[3] 6G4Society. 2024. *D1.1 Societal Aspects in 6G Technology: Concerns, Acceptance Models and Sustainability Indicators*. https://6g4society.eu/wp-content/uploads/sites/118/2025/01/6G4Society_D1.1_SOCIETAL_ASPECTS_IN_6G_TECHNOLOGY_disclaimer_f.pdf.
[4] GSMA. 2023. *6G's Green Credentials: The Role of Mobile Technology in the Climate Emergency*. https://www.gsma.com/solutions-and-impact/connectivity-for-good/mobile-for-development/wp-content/uploads/2021/03/The-Role-of-Digital-and-Mobile-Enabled-Solutions-in-Addressing-Climate-Change-Final..pdf.
[5] Siemens. 2025. *Product Carbon Footprint*. https://www.siemens.com/asean/en/company/sustainability/product-carbon-footprint.html
[6] Id.

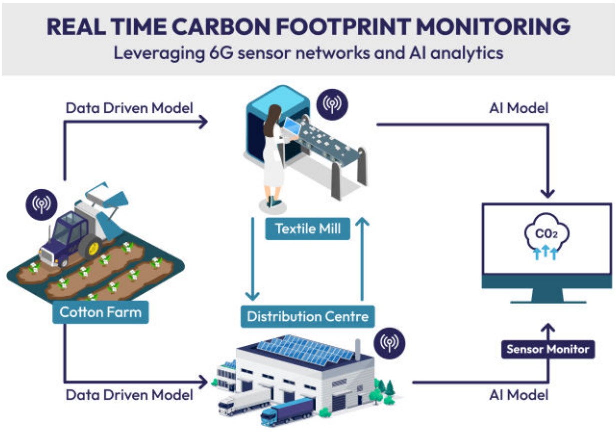

Figure 1. Schematics of real-time carbon footprint monitoring services leveraging 6G's ultra-dense sensor networks in a typical cotton value chain. Chart generated by the authors

- Automated carbon accounting platforms that integrate with enterprise systems to enable real-time emissions reporting and optimization are needed.[7] These platforms could leverage APIs and data analytics to continuously collect activity data (e.g., energy usage, logistics, procurement), apply standardized emission factors, and generate actionable insights. For example, by identifying carbon-intensive suppliers or logistics routes, the system can recommend greener alternatives or trigger alerts for exceeding emissions thresholds, thereby supporting compliance and decarbonization strategies. For instance, an enhanced optimization model for sustainable, multi-modal transportation routing that incorporates carbon-emissions constraints was recently proposed by the research—effectively identifying carbon-intensive routes and recommending greener alternatives.[8]

- Predictive modelling services that simulate and forecast environmental impacts across operations, enabling organizations to proactively mitigate their ecological footprint, and meet long-term sustainability goals, are necessary. Ultimately, by integrating historical data, operational metrics, and external factors such as climate projections or regulatory changes, these modelling services enable early identification of environmental risks. For instance, a manufacturing firm might use these models to simulate the long-term impact of raw material sourcing strategies, allowing it to shift to more sustainable suppliers or redesign products to reduce lifecycle emissions.[9]

(ii) Energy Optimization Ecosystems:

- They include, e.g., comprehensive energy optimization platforms utilizing massive IoT connectivity to reduce industrial and residential energy consumption through intelligent load balancing and predictive maintenance. Such systems collect real-time data from connected devices, such as smart meters, and use algorithms to detect inefficiencies, forecast demand, and optimize energy distribution. For example, in a manufacturing facility, the platform can shift non-critical operations to off-peak hours to lower energy costs, while also predicting equipment failures to prevent downtime and unnecessary energy waste.[10]

- Smart grid orchestration services could optimize in an optimal way the renewable energy distribution and storage across multiple stakeholders.[11] These services could, for instance, use real-time data, AI-driven forecasting, and distributed energy resource (DER) management to balance grid loads, maximize renewable integration, and reduce reliance on fossil fuels.[12] In Germany, *TenneT* partners with *Sonnen* to balance grid loads using a distributed network of residential batteries. In the 6G future, orchestration platforms could go further by coordinating in real time with electric vehicles, solar farms, and smart appliances, using AI to forecast demand and instantly reallocate stored energy across cities or industrial parks.[13]

- Building-as-a-service (BaaS) models where 6G enables autonomous energy management systems that guarantee specific efficiency outcomes is another solution with high potential. Namely, they integrate data from sensors, building management systems, and external conditions (e.g., weather) to make real-time decisions on lighting, HVAC, or energy storage to accommodate individual needs. These models shift buildings from static assets to dynamic, service-oriented platforms. An example is the *Empa* NEST innovation platform in Switzerland (see Figure 2 below). NEST demonstrates modular, smart building environments where different living and working units are equipped with real-time sensing, decentralized control systems, and predictive analytics. These systems automatically adjust lighting, heating, and energy storage according to occupancy patterns, weather forecasts, and grid demand[14]. In a future 6G context, BaaS platforms like NEST would be enhanced by ultra-reliable low-latency communication,

[7] Das, Resul, Yahaya Adam, Iliyasu, and Oztop, Hakan F. 2025. Green IoT for energy efficiency: Enabling technologies, challenges, and future research directions. In *Thermal Science and Engineering Progress*, 62:103592. https://doi.org/10.1016/j.tsep.2025.103592.

[8] Teixeira, Antoine and Lefèvre, Julien. 2025. Global supply chains and domestic climate policy: Addressing the substantial material-related carbon footprint of final consumption in France. In *Journal of Industrial Ecology*. https://doi.org/10.1111/jiec.70001.

[9] Id.

[10] For this and similar models, see an extensive state-of-the-art of Terbrack, Hajo, Claus, Thorsten, and Herrmann, Frank. 2021. Energy-Oriented Production Planning in Industry: A Systematic Literature Review and Classification Scheme. In *Sustainability*, 13(23):13317. https://doi.org/10.3390/su132313317.

[11] The ProValet Team. 2025. *How AI for energy management is revolutionizing the future of power and sustainability*. ProValet. Retrieved June 12, 2025, from https://www.provalet.io/guides-posts/ai-for-energy-management.

[12] Pandiyan, Palanisamy, Saravanan, Subramanian, Kannadasan, Raju, Krishnaveni, Sasikala, Alsharif, Mohammed H., and Kim, Mun-Kyeom. 2024. A comprehensive review of advancements in green IoT for smart grids: Paving the path to sustainability. In *Energy Reports*, 11:5504–5531.https://doi.org/10.1016/j.egyr.2024.05.021. See also Singh, Arvind R., Sujatha, M. S., Kadu, Akshay D., Bajaj, Mohit, Addis, Hailu Kendie, and Sarada, Kota. 2025. A deep learning and IoT-driven framework for real-time adaptive resource allocation and grid optimization in smart energy systems. In *Scientific Reports*, 15:19309. https://doi.org/10.1038/s41598-025-02649-w.

[13] Sonnen Group. 2023. *Sonnen: Electric cars as power storage unit*. https://sonnengroup.com/press/sonnen-electric-cars-as-power-storage-unit/.

enabling more granular, synchronized coordination between subsystems (HVAC, solar panels, battery storage, ventilation) and broader smart grid ecosystems. This would allow service providers to offer performance-based contracts, where building operators are paid based on outcomes such as CO_2 reduction, energy efficiency, or indoor air quality, rather than just infrastructure deployment.

Figure 2. [a] NEST building at Empa in Switzerland with heat pump [b] and water storage tanks [c] IoT sensors. Source[14]

(iii) Circular Resource Marketplaces:

- Advanced material tracking platforms, where 6G enables precise monitoring of materials throughout their entire lifecycle, from extraction and manufacturing to reuse and recycling are another proposed solution. By combining 6G with technologies like digital twins, blockchain-based traceability, and ultra-reliable data transmission, these platforms can help stakeholders verify material origin, assess sustainability potential, and automate reverse logistics.[15] As an example, *Circularise*, a company based in the Netherlands uses blockchain to track plastics, metals, and composites across supply chains to verify circularity and material origins (see Figure 3 below).[16] With 6G connectivity and IoT-enabled tagging, platforms like *Circularise* could match real-time availability of reclaimed materials (e.g., from construction or electronics) with manufacturers looking to source secondary materials, reducing virgin resource demand and landfill waste.

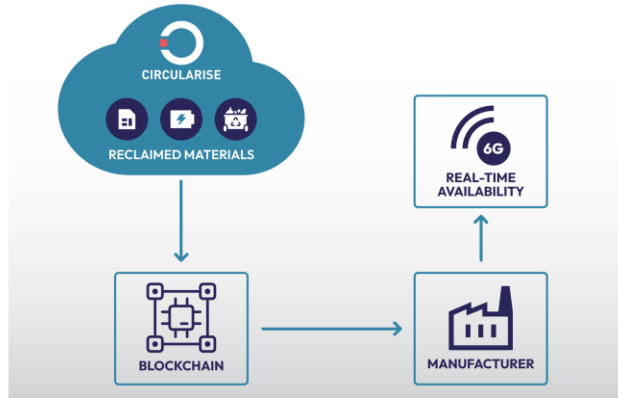

Figure 3. Example of blockchain-enabled circular resource tracking with Circularise. Chart generated by the authors

- Waste-to-resource matching services that connect waste generators with potential users through real-time material quality and availability data have a lot of potential. Such platforms could, for example, use IoT sensors, AI-driven classification, and digital marketplaces to assess waste streams, such as industrial byproducts, packaging, or material waste, and match them with organizations that can repurpose them as raw materials. Existing platforms such as Excess Material Exchange (EME) can benefit from this service.[17] EME is a digital marketplace that matches industrial byproducts (like surplus textiles, packaging, or chemicals) with organizations that can reuse them. A 6G-enhanced version could use edge analytics and sensor-fed quality assessments to instantly verify material suitability and automate logistics, turning waste into a real-time trading commodity.

- Product-as-a-service models that maintain continuous connectivity with products to optimize performance, extend lifespan, and facilitate circular reuse are next on our list. The 6G connectivity, together with embedded sensors and cloud-based analytics, can enable these systems to monitor usage patterns, detect wear or inefficiencies, and enable proactive maintenance and upgrades. Existing systems such as *Philips* lightning-as-a-service would benefit from 6G connectivity.[18] They offer lighting infrastructure as a service to airports and office buildings, maintaining ownership while guaranteeing energy performance.[19] With 6G, such models could integrate continuous feedback loops via embedded sensors to predict failure, optimize light levels dynamically, and trigger autonomous maintenance workflows, making the service smarter, not just efficient.

[14] Heer, Philipp, Derungs, Curdin, Huber, Benjamin, Bünning, Felix, Fricker, Reto, Stoller, Sascha, and Niesen, Björn. 2024. Comprehensive energy demand and usage data for building automation. In *Scientific Data*, 11:469. https://doi.org/10.1038/s41597-024-03292-2

[15] Circularise. 2025. *Circularise showcases circular economy vision at Japan–Netherlands High Tech DX Symposium*. https://www.circularise.com/press-releases/circularise-at-high-tech-dx.

[16] Id.

[17] Excess Materials Exchange. 2025. *Excess Materials Exchange: Seamless sustainability, amplified profits*. https://excessmaterialsexchange.com/.

[18] Meteor Electrical. 2014. *Philips introduces lighting as a service*. https://www.meteorelectrical.com/blog/philips-introduces-lighting-as-a-service.html.

[19] Id.

Currently, some SNS actors implement certain sustainability principles with relation to resource optimization, energy efficiency, and circularity. [20] To balance optimism with realism, while the above models are extremely forward-looking, there are also some limitations in the current SNS ecosystem. For instance, GHG reduction is not that often explicitly incorporated in the work of 6G R&I actors, Life Cycle Assessments (LCA) and circular design are rarely used in the models, and rebound effects are not often incorporated in the relevant considerations.[21]

For example, as per a recent SNS JU White paper reporting the results of sustainability-related work of 27 SNS JU projects—including 6G4Society—in total (16 projects from Call 1 and 11 from Call 2), 5 projects out of 27 targeted GHG reduction explicitly in their work.[22] This number shows a modest but definite step toward more efforts in this direction. Another example is the TIMES6G consortium (also SNS JU) working on how sensing and network intelligence can be combined to enable context-aware energy management in wireless networks, aiming to support greener connectivity models that balance performance with environmental impact. [23] On the one hand, TIMES6G is a typical example of integrating environmental sustainability from both technological and architectural standpoints. On the other hand, this type of approach doesn't seem to address rebound effects—hence the risk that energy efficiency improvements could lead to increased consumption.

Our insight here is that incorporating the **rebound effect** as an **important variable** will **sharpen environmental sustainability models** and business foresight.

Another empirical aspect is that the answers to the questionnaire in the same SNS JU White paper, cited above, show that the circular economy models are barely present in practice, with few projects implementing LCA or circular design. Our inference here is that **actionable societal and economic business models**, **targeted policy incentives**, and practical **eco-design toolkits** are needed to support and make happen the above conceptual vision of environmental sustainability business models. We analyze those avenues in the sections that follow.

3 Societal Sustainability Business Models

Social sustainability itself is the least systematically addressed from the three sustainability dimensions (i.e. environmental, social, and economic): e.g., the majority of SNS JU projects reference some social value—primarily digital and social inclusion, safety, trust, and privacy—definitions vary widely, and no projects specify metrics for evaluating social impact.[24] There is also at present little emphasis on cultural, well-being, or ethical dimensions.[25] Building on a handful of recent projects and, to date, quite scarce research, below are our assumptions of the most optimal societal sustainability business model solutions.

Digital Inclusion Services

The pathway to 6G success depends on achieving five critical societal and economic outcomes: digital equity, trust, sustainability, economic growth, and quality of life. These aspects drive **innovative business models specifically designed to bridge digital divides and ensure truly equitable access to advanced connectivity.**

Community-Centric Platforms

Societal sustainability enables entirely new categories of community-focused services, such as:

(i) Hyperlocal Sustainability Networks:

- Community resilience platforms that connect neighborhoods for resource sharing, environmental monitoring, and collective sustainability initiatives.[26]
- Local circular economy marketplaces that enable communities to trade, share, and optimize resource utilization within their immediate geographic area.[27]
- Citizen science networks that leverage 6G's sensing capabilities to engage communities in environmental monitoring and data collection. [28]

(ii) Digital Twin Cities:

- Comprehensive urban optimization platforms that create digital replicas of cities to improve planning, reduce resource consumption, and enhance citizen services while generating revenue through operational efficiency gains.[29]
- Participatory governance platforms that enable real-time citizen engagement in urban planning and policy decisions. [30]
- Social infrastructure optimization services that help cities better allocate resources for maximum community benefit.[31]

(iii) Inclusive Connectivity Models:

[20] SNS JU. 2025. *White paper Sustainability in SNS JU Projects: Targets, Methodologies, Trade-offs and Implementation Considerations Towards 6G Systems*. https://doi.org/10.5281/zenodo.15555292.
[21] Id.
[22] Id.
[23] TIMES6G. 2022. *THz Industrial Mesh Networks in Smart Sensing and Propagation Environments*. HORIZON-JU-SNS-2022. http://www.times6g.eu/.
[24] SNS JU. 2025. White paper, *supra*, note 20.
[25] Id.
[26] ENFORCE. 2025. https://join-enforce.eu/.
[27] Arifuzzaman (Arif) Sheikh, Steven J. Simske, and Edwin K. P. Chong. 2024. Evaluating Artificial Intelligence Models for Resource Allocation in Circular Economy Digital Marketplace. In *Sustainability*, 16(23):10601. https://doi.org/10.3390/su162310601.
[28] ENFORCE, *supra*, note 26.
[29] Billey, Anna, and Wuest, Thorsten. 2024. Energy digital twins in smart manufacturing systems: A case study. In *Robotics and Computer-Integrated Manufacturing*, 88:102729. https://doi.org/10.1016/j.rcim.2024.102729.
[30] ENFORCE, *supra*, note 26.
[31] Yin Cui and Yu Sun. 2019. Social benefit of urban infrastructure: An empirical analysis of four Chinese autonomous municipalities. In *Utilities Policy*, 58:16–26. https://doi.org/10.1016/j.jup.2019.03.001.

- Innovative pricing structures that make 6G accessible to underserved populations through community-based ownership models and sliding-scale pricing.[32]
- Partnership frameworks between operators, local governments, and community organizations to ensure universal access.[33]
- Digital literacy and empowerment programs are integrated with connectivity services to maximize social impact.[34]

Aside from the prospective solutions in the above research scenarios and/or the ongoing R&I projects that are not finished yet, in terms of more concrete numbers, for example, among the answers to the questionnaire of the SNS JU White paper on sustainability in connectivity, social sustainability presented the most promising sustainability area for progress out of the three (environmental, social, economic). Namely, while 85% of projects referenced some social value, primarily digital and social inclusion, safety, trust, and privacy, the divergence of approaches and definitions highlighted a rich landscape of interpretations and opportunities.[35] Although **specific metrics for evaluating social impact have not yet been defined**, this gap suggests a valuable direction for future development, including in societal sustainability business models.

Similarly, the relatively limited focus on general **cultural, well-being, and ethical dimensions** opens the door for deeper exploration in societal sustainability business models. More concretely, we should consider expanding the social sustainability lens further, to reflect areas like **mental health, cultural cohesion**, and **stakeholder trust**, as per the latest study, areas underexplored in the SNS JU projects but increasingly important. For example, 6G4Society highlighted in its work those gaps that are opportunities for future R&I and investment.

4 Economic Sustainability Business Models

Economic sustainability is at present primarily framed around cost-efficiency, industrial growth, and technological innovation: e.g., how to improve affordability for stakeholders, or enable new market opportunities.[36] What is underexplored, for instance, are: the relationship between economic sustainability and the other two sustainability pillars, e.g. more efficient use of resources or digital skills, as well as broader macroeconomic impacts outside the 6G system, and/or economic equity outside the telecommunications ecosystem.[37] Below we discuss and expand these and other currently underexplored avenues for economic sustainability business models.

Value-Based Pricing Evolution

The economic sustainability imperative is catalyzing the emergence of a fundamentally new 6G business ecosystem characterized by novel stakeholders, transformed roles, and potentially conflicting perspectives on business conduct. This transformation shifts the industry from traditional volume-based pricing toward value-based models that create unprecedented revenue opportunities.

Ecosystem Orchestration

Economic sustainability enables sophisticated platform business models:

(i) Sustainability-as-a-Platform:

- Comprehensive platforms where 6G infrastructure enable third-party sustainability applications and services, creating multi-sided markets for environmental and social solutions. Such a platform could, for instance, be modular, cloud-native environments with standardized APIs and edge computing capabilities, allowing seamless integration of diverse services and real-time data exchange.[38]
- Developer ecosystems focused on sustainability applications, with revenue sharing models that incentivize positive impact creation. Monetization strategies could include tiered access models, transaction fees on verified impact actions (e.g., carbon offsets, waste recovery), and usage-based billing tied to data volume or sensor interactions.[39]
- Integration platforms that connect various sustainability tools and services into cohesive enterprise solutions. These can act as orchestration layers that unify data streams, compliance tools, and operational dashboards, offering enterprises plug-and-play access to a full suite of sustainability functionalities.[40]

(ii) Impact-Driven Partnerships:

- Strategic alliances between telecom operators, governments, and NGOs that monetize measurable social and environmental outcomes rather than traditional connectivity metrics. Such an outcome-based approach

[32] Thakur, Madhur et al. 2025. Enhancing Health Equity and Patient Engagement in Diabetes Care: Technology-Aided Continuous Glucose Monitoring Pilot Implementation Project. In *JMIR Diabetes*, 10:e68324. https://doi.org/10.2196/68324.
[33] INPACE. 2025. https://inpacehub.eu/.
[34] Id.
[35] SNS JU. 2025. White paper, *supra*, note 20.
[36] Id.
[37] Id.
[38] See e.g. Arkko, Jari, Björn, Michael, John, Wolfgang, Sjöberg, Johan, Wildeman, Mattias, Wikström, Gustav, and Öhlén, Peter. 2024. *Beyond bit-pipes – new opportunities on the 6G platform.* In *Ericsson Technology Review*, 6 July 2024. https://www.ericsson.com/en/reports-and-papers/ericsson-technology-review/articles/6g-platform. For scientific research examples, see e.g. Yrjölä, Seppo, Ahokangas, Petri , and Matinmikko-Blue, Marja. 2020. Sustainability as a challenge and driver for novel ecosystemic 6G business scenarios. In *Sustainability*, 12(21):8951. https://doi.org/10.3390/su12218951.
[39] Gaikovina Kula, Raula, and Treude, Christoph. 2025. *Open Source at a Crossroads: The Future of Licensing Driven by Monetization.* Preprint, March 2025, 9 pages. https://doi.org/10.1145/nnnnnnn.nnnnnnn..
[40] Jose, Ashley. 2023. A holistic framework for unifying data security and management in modern enterprises. In *Proceedings of the World Academy of Science, Engineering and Technology International Journal of Social and Business Sciences.* https://www.researchgate.net/publication/380153247_A_Holistic_Framework_for_Unifying_Data_Security_and_Management_in_Modern_Enterprises.

will further enable transparent reporting and financial reconciliation across different stakeholders.[41]

- Social impact bonds facilitated by 6G's measurement capabilities, where returns are tied to achieve sustainability outcomes. For example, governments and NGOs in various development contexts are piloting impact bonds tied to sanitation or clean water delivery.[42] With 6G, platforms could verify delivery in real time via mobile IoT sensors and enable instant outcome-triggered payments across multiple stakeholders (e.g., telecoms, municipalities, donor agencies), using verifiable social impact as the revenue metric.
- Cross-sector collaboration platforms that enable new forms of public-private partnerships focused on global challenges.[43]

(iii) Regenerative Business Models:

- Business frameworks are designed to create positive environmental and social impact while generating sustainable profits. More precisely, we consider the following:
- Restoration economy services that use 6G capabilities to monitor and optimize ecological restoration projects. For example, *Land Life* uses drones, soil sensors, and remote imaging to monitor reforestation projects.[44] A 6G-enabled version could automate outcome-based payments through smart contracts, where investors or public entities fund verified carbon drawdown, biodiversity gains, or water retention, turning ecological restoration into a viable business service.
- Community wealth-building platforms that keep economic value circulating within local communities.

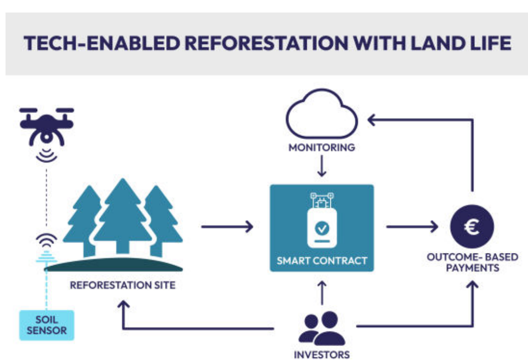

Figure 4. Example of 6G inspired regenerative business model with tech-enabled reforestation and outcome-based payments based on Land Life model. Chart generated by the authors

5 Integrated Triple-Bottom-Line Models

Multi-Stakeholder Value Creation

The holistic approach to 6G development considers scenarios across three critical themes: user experience, business sustainability, and geopolitics, analyzed through economic, societal, and environmental lenses. This comprehensive perspective enables business models that simultaneously address all three sustainability dimensions, creating unprecedented value propositions.

Outcome-Based Services

What we mean here is how *success* could be measured: i.e., how **to link outcomes to standardized measurement approaches**. In 6G4Society, we do explore such approaches, through working on, for example, Key Value Indicators (KVIs).[45] Aligning the triple-bottom-line models with robust, standardized metrics, such as KVIs, could address **how success will be measured**, provide **a clearer roadmap for impact assessment**, and support the growing interest in meaningful, **evidence-based sustainability metrics**.[46]

The integration of multiple sustainability dimensions enables sophisticated service models, such as:

(i) Smart City Sustainability Contracts:

- Performance-based agreements, where network operators receive payment based on achieved environmental and social outcomes rather than traditional connectivity metrics.
- Long-term city partnership models that align operator incentives with urban sustainability goals.
- Integrated urban service platforms that optimize multiple city functions simultaneously.

(ii) Industrial Transformation Services:

- Comprehensive enterprise services that help organizations reduce their environmental footprint while simultaneously improving operational efficiency and social impact.
- Industry 4.0 sustainability platforms that integrate production optimization with environmental and social monitoring.
- Supply chain transformation services that optimize for multiple sustainability criteria simultaneously.

(iii) Wellness and Quality-of-Life Platforms:

- Integrated health and wellness ecosystems that leverage 6G's capabilities to improve public health outcomes and social well-being.
- Community health monitoring systems provide early warnings for environmental health risks.

[41] Connect Europe. 2024. *External Expertise for Accelerating Sustainability in Telecoms – VS/2023/101102394*. April 12, 2024. Research Report.
[42] Canada Border Security Agency. 2023. *Outcomes Based Funding*. https://cbsa.global/outcomesfunding..
[43] See e.g. ENFORCE, *supra*, note 26.
[44] Land Life Company. 2025. *Innovation: The tech & science behind Land Life*. https://landlifecompany.com/en-us/innovation.
[45] 6G4Society. 2024. *D1.1*, *supra*, note 3. See e.g. pp. 4, 18, 24.
[46] 6G4Society. 2024. *D4.3 Exploitation Report I*. https://6g4society.eu/wp-content/uploads/sites/118/2025/03/6G4Society_D4.3_Exploitation-Report_v1.1_05.02.2025.pdf. See pp. 86-94.

- Social connectivity platforms are designed to address isolation and build community resilience.

6 Innovation Enablers

Data Monetization for Good
6G's unprecedented data collection and processing capabilities enable entirely new business models centered on anonymized sustainability insights, comprehensive environmental monitoring, and precise social impact measurement. These capabilities transform data from a privacy concern into a tool for positive social and environmental change.

Collaborative Ecosystems
Circular business models seek economically viable approaches to continuously reuse products and materials while utilizing renewable resources wherever possible. 6G provides the essential connectivity and data exchange infrastructure necessary for these sophisticated collaborative circular economy models, enabling coordination across multiple stakeholders and supply chains.

Cross-Sector Innovation
The sustainability imperative breaks down traditional industry silos, enabling new forms of collaboration between telecommunications, energy, agriculture, healthcare, education, and environmental sectors. This cross-pollination creates opportunities for breakthrough innovations that address multiple challenges simultaneously.

7 Conclusion

The **sustainability imperative** fundamentally **transforms 6G** from a **traditional connectivity business** into a **comprehensive platform for creating shared value across environmental, social, and economic dimensions**. This transformation opens entirely new markets and revenue streams while simultaneously addressing pressing global and local societal and economic challenges.

The success of these new business models depends on several critical factors: robust multi-stakeholder collaboration, supportive policy and regulatory frameworks, significant investment in both technology and social infrastructure, and a fundamental shift in how we measure and value business success. Organizations that can successfully navigate this transformation will not only achieve financial success but will also play a crucial role in building a more sustainable and equitable future.

Specific innovations highlighted throughout this work, such as Sustainability-as-a-Platform, circular resource marketplaces, and impact-driven partnerships, exemplify this ongoing shift toward sustainability-oriented value creation. These approaches **reframe connectivity from merely a service** to the **foundation for dynamic, cross-sector ecosystems where environmental and social impacts are actively mobilized, monetized, and operationalized**.

To ground this vision in actionable footings, short-term steps include piloting modular platform architectures, developing outcome-based monetization models, and nurturing early-stage developer ecosystems focused on applications with measurable climate and social outcomes. Early indicators of success may include increased third-party platform participation, demonstrable reductions in emissions or material waste, and new forms of investment and collaboration enabled by real-time, impact-driven data infrastructure.

Given the transformative nature of the proposed business models, **the role of citizens and policy frameworks is paramount**. For example, 6G4Society contributes to the European Commission's priority of establishing secure, resilient, performant, and sustainable digital infrastructures, as per Article 4 of the Digital Decade, thus participating in the Commission's priority 'A Europe Fit for the Digital Age', fostering innovation and increasing resource-use efficiency.[47] The project also aligns with three out of four key areas (all four are: Skills, Infrastructures, Business, Government) highlighted in the EU Digital Compass for the 2030 Digital Decade Initiative,[48] and regarding the business models, 6G4Society directly contributes to the sustainable digital transformation of businesses. Finally, we also provide evidence for evidence-based, relevant policy making regarding social acceptance through our Citizen Survey.[49]

The opportunity is unprecedented, but so is the responsibility. The choices made in designing and deploying 6G systems will have profound implications for environmental sustainability, social equity, and economic development for decades to come. By embracing innovative business models that integrate all three dimensions of sustainability, we can ensure that 6G becomes a powerful force for positive change in the world.

ACKNOWLEDGMENTS

This work was partly supported by the 6G4SOCIETY project. 6G4SOCIETY project has received funding from the Smart Networks and Services Joint Undertaking (SNS JU) under the European Union's Horizon Europe research and innovation program under Grant Agreement No 101139070. This work has received funding from the Swiss State Secretariat for Education, Research and Innovation (SERI). Views and opinions expressed are, however, those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.

We are also grateful to Christos Tselebis (Digital for Planet) for the graphic design of Figures 1, 3, and 4.

[47] European Commission; European Parliament; Council of the European Union. 2022. *Decision (EU) 2022/2481 of 14 December 2022 establishing the Digital Decade Policy Programme 2030.* In Official Journal of the European Union, L 323:4–26. https://eur-lex.europa.eu/eli/dec/2022/2481/oj.

[48] European Commission. 2021. *2030 Digital Compass: The European Way for the Digital Decade*. COM(2021) 118 final.

[49] 6G4Society. 2024. *Citizen Survey*. https://6g4society.eu/citizen-survey/.