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Digital Sustainability Trade-Offs: Public Perceptions of Mobile Radiation and Green Roofs

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Abstract:

This paper explores how public perceptions influence the interplay between Digital Sustainability (DS), public health, and environmental policy, particularly regarding the effects of mobile radiation on green roofs. While green roofs are recognized for their ecological advantages, the impact of mobile radiation exposure, especially from 5G technology, has not been thoroughly examined in Information Systems (IS) research. Through a Discrete Choice Experiment (DCE) involving an urban sample from the French population, our findings indicate a significant preference for funding research focused on human health compared to plant health, with willingness to pay (WTP) estimates for human health nearly twice as high. Nonetheless, the considerable support for plant health research underscores the importance of addressing both human and environmental aspects in policy formulation. This study contributes to the growing DS dialogue by demonstrating how cognitive, emotional, and moral perceptions shape public backing for research on mobile radiation. These findings enhance our understanding of how public attitudes influence the adoption and regulation of green technologies in urban environments. Our research provides insights for IS researchers and policymakers, advocating for balanced funding approaches and the integration of cognitive, emotional, and ethical factors into policy frameworks to foster effective public engagement and regulatory policies.

Keywords: Digital Sustainability (DS), Green Roofs, Mobile Radiation, Risk Perception, Public Health, Willingness to Pay (WTP), Environmental Policy.

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1 Introduction

The rapid growth of urbanization, along with the extensive use of digital technologies, has led to an urgent demand for solutions that foster environmental sustainability while embracing technological progress (McCarthy et al., 2024; Touboul & Kozan, 2020; Pernici et al., 2012). This intersection is especially pertinent in the field of Information Systems (IS), which aims to utilize digital technologies to promote sustainability (Kotlarsky et al., 2023). However, the challenge of integrating these technologies, such as mobile base stations, with sustainable practices (Corbett, 2013) like green roofs (Vijayaraghavan, 2016) involves a complex trade-off. Green roofs offer significant ecological, social, and economic advantages such as managing stormwater, mitigating urban heat islands, and boosting biodiversity, but they also face potential risks, particularly from radio-frequency electromagnetic fields (RF-EMFs) linked to mobile technologies like the 5th generation of mobile technology (5G-NR) (Vijayaraghavan, 2016; Czemiel Berndtsson, 2010). This trade-off is important for IS research, as it requires balancing the short-term benefits of technological advancements with long-term environmental and health implications (Gasmi et al., 2024).

The concept of "Digital Sustainability" (DS) has come to the forefront as a holistic approach to tackling various challenges, highlighting the increasing convergence of digital technologies with sustainability efforts aimed at improving environmental, social, and economic results (Kotlarsky et al., 2023). DS goes beyond the earlier notions of Green IT and Green IS (El Idrissi & Corbett, 2016), which mainly concentrated on creating environmentally friendly technology and using IS to meet environmental goals (Watson et al., 2010). Instead, it covers a wider range, focusing on the strategic use of digital tools like data analytics, the Internet of Things (IoT), and artificial intelligence (AI), to optimize resource utilization, boost operational efficiency, and reduce environmental impacts across different sectors, including urban development (Pappas et al., 2023; Chatterjee et al., 2022; Harfouche et al., 2022). However, merging green roofs with digital infrastructure such as mobile base stations requires a closer look at the potential risks linked to RF-EMF exposure, especially concerning human health and plant life. The practice of growing plants on rooftops, which dates to around 500 BC, has gained renewed interest due to urbanization and the rising demand for sustainable urban solutions. Green roofs provide a variety of benefits that align with the United Nations (UN) Sustainable Development Goals (SDGs), particularly SDG 11 (Sustainable Cities and Communities) and SDG 13 (Climate Action) (Vijayaraghavan, 2016). These advantages include increasing green spaces, enhancing stormwater management, lowering energy use, and improving air and water quality. They also help address urban environmental challenges, such as reducing noise pollution and enhancing aesthetic appeal, contributing to the creation of more livable cities (Czemiel Berndtsson, 2010).

The widespread use of mobile technologies, particularly the installation of telecommunication antennas on rooftops, brings about new challenges (Shin & Dedrick, 2024; Li et al, 2022). These antennas are typically placed on rooftops to enhance signal propagation, which results in roofs being exposed to increased levels of RF-EMFs (Chiaraviglio et al., 2018). This concern is amplified with the advent of 5G technology, which operates at higher frequencies and employs more directive and dynamic antennas, potentially leading to new exposure risks and raising questions about the impact of RF-EMFs on human and animal health, as well as on plant life (Karipidis et al., 2023; ANSES, 2022; Gomez et al., 2011). In this scenario, green roofs, while offering considerable ecological and social advantages (Vijayaraghavan, 2016), may also be subjected to elevated levels of mobile radiation due to their closeness to RF-EMF sources (Recuero Virto et al., 2024). On one side, green roofs can serve as a biological barrier, scattering and absorbing RF-EMFs, which could help reduce human exposure on roofs, balconies, and upper-floor apartments (Gomez et al., 2011). Conversely, the vegetation on green roofs might diminish RF-EMF reflection, further lowering exposure levels by creating a diffuse reflection instead of a specular one (EPRS, 2021). However, this protective benefit is countered by the reality that the vegetation itself is also significantly exposed to RF-EMFs.

This study examines public perceptions and preferences regarding funding for research on the trade-offs between health, environmental, and economic implications of RF-EMF exposure on green roofs. Gaining insight into these trade-offs is essential for guiding policy decisions, crafting effective communication strategies, and securing public backing for green roof projects that align with the SDGs (Pophof et al., 2022; Carson & Czajkowski, 2014). Accordingly, there is a need to investigate how public perceptions of these trade-offs affect the acceptance and endorsement of sustainable digital technologies (Pinget et al., 2015). For example, existing literature has largely concentrated on either the advantages of sustainable technologies (Leidner et al., 2022) or the dangers linked to mobile radiation (Gasmi et al., 2024), with few studies addressing the intersection of these topics, especially regarding public perception and support (Brosch & Steg, 2021). By examining public perceptions, this research will reveal the cognitive, emotional, and ethical factors that shape these preferences, thereby contributing to the broader discussion on sustainable urban development in IS research (Kotlarsky et al., 2023; Brosch & Steg, 2021).

In the subsequent sections, we will first present a comprehensive literature review and theoretical development, exploring the foundational concepts of DS and their relevance to the integration of green roofs with digital infrastructure. Following this, the methodology employed in this study will be detailed, outlining the survey design and data collection process. The survey results will then be presented, providing insights into public perceptions and preferences regarding the trade-offs between the benefits of green roofs and the risks associated with RF-EMF exposure. The discussion section will analyze these findings in the context of existing IS literature and will address the implications for policy and future research, contributing to the creation of resilient and sustainable urban environments by balancing the benefits of green roofs with the risks of RF-EMF exposure. The conclusion will propose avenues for future research to further explore the intersection of digital technologies and sustainable urban development.

2 Literature Review

There are existing regulations designed to safeguard human health from mobile radiation, particularly about thermal effects (EPRS, 2021). These regulations assume that biological effects are caused solely through tissue heating and that no effects occur below certain thresholds. However, these assumptions remain controversial, as adverse effects have been observed below these thresholds, including the non-thermal induction of reactive oxygen species, DNA damage, cardiomyopathy, carcinogenicity, sperm damage, and neurological effects (e.g., electromagnetic hypersensitivity). Furthermore, there are no comparable protective measures for the effects of thermal heating on non-human organisms, despite evidence indicating that RF-EMFs can also exert these effects on plants and animals (ICBE-EMF, 2022). Small animals are especially sensitive to frequencies above three gigahertz due to their size (De Borre et al., 2021; Simkó & Mattsson, 2019; Thielens et al., 2018). Even small shifts in incident power density can significantly increase the amount of power absorbed by insects (Thielens et al., 2020). Additionally, attention should be given to the exposure of plants to RF-EMF starting from the 26 gigahertz band, as both tissues and organs may be affected, owing to the high surface area-to-volume ratio (Vian et al., 2016).

More broadly, the biological effects of artificial RF-EMFs on non-human organisms have been relatively well documented; however, the potential biophysical mechanisms underlying these effects have yet to be substantiated (Pophof et al., 2022; Kaur et al., 2021). Additional data and high-quality analyses under field-realistic exposure conditions are necessary to determine the effects of RF-EMFs on wildlife (Kaur et al., 2021; Vanbergen et al., 2019; Goudeseune et al., 2018). Regarding plants, oxidative effects and stress appear to play a significant role (Porcher et al., 2023; Tran et al., 2023; Kundu et al., 2021a; Kundu et al., 2021b; Roux et al., 2008; Vian et al., 2006). The effects of RF-EMF exposure on plants are largely dependent on wave frequency, power density, and the duration of exposure, as well as the type of plant, making it difficult to draw definitive conclusions (Tran et al., 2023; Czerwiński et al., 2023; Kaur et al., 2021; Levitt et al., 2021; Kumar et al., 2020; Surducan et al., 2020; Gremiaux et al., 2016; Halgamuge, 2017).

Biophysical mechanisms that explain the observed correlations between RF-EMF exposure and biological effects on animals have yet to be established (Pophof et al., 2022). RF-EMF exposure has been correlated with changes in behavior in adult mice previously exposed in utero, increased oxidative stress in brain tissue in guinea pigs, and memory and learning effects in rodents (Lai, 2018; Aldad et al., 2012; Daniels et al., 2009; Meral et al., 2007). Additionally, there is evidence linking RF-EMF exposure to reduced hatching ratios, increased expression of stress-related genes in honeybees, as well as behavioral disorders and changes in the abundance of wasps, bees, and hoverflies (Migdal et al., 2023; Odemer & Odemer, 2019; Sharma & Kumar, 2010). In general, there is evidence of the developmental effects of RF-EMF exposure on insects (De Paepe et al., 2022).

Green roofs offer numerous environmental benefits, such as reducing energy consumption, improving air quality, and promoting biodiversity (Gomez et al., 2011). However, a significant trade-off arises when considering the potential effects of RF-EMF exposure on plants, which could negatively impact plant health. This trade-off is not simply between having green roofs and not having them. Rather, it involves balancing the sustainability benefits of green roofs with the potential harm to plant health due to exposure to electromagnetic radiation. While green roofs contribute to broader environmental goals, such as reducing the urban heat island effect, they could also expose plants to harmful electromagnetic fields, potentially affecting their growth and resilience. Hence, the dual nature of green roofs presents significant environmental advantages while also facing potential risks from RF-EMF exposure, revealing a gap in research within the IS field.

2.1 DS: A New Research Paradigm

The concept of sustainability in IS research has undergone significant changes over the years, initially concentrating on Green IT and Green IS as key focus areas (Kotlarsky et al., 2023). However, it has become clear that a narrow focus on IT alone is insufficient, prompting a broader perspective. This shift has given rise to the idea of "digital sustainability," which combines the principles of Green IT/IS with the extensive role of digital technologies in achieving sustainability objectives across environmental, social, and economic dimensions (Monteiro et al., 2022; Watson et al., 2010). DS can be defined as the creation and use of digital resources, tools, and technologies that support long-term sustainability in environmental, social, and economic contexts (Kotlarsky et al., 2023). This concept acknowledges that digital technologies are essential for developing and maintaining sustainable systems, affecting various aspects such as energy consumption, resource management, social equity, and economic growth (Monteiro et al., 2022). DS highlights the fact that digital technologies increasingly influence our physical and social environments, making it a vital area of research within IS (Watson et al., 2010). This transition is especially pertinent in situations where new technologies intersect with environmental issues, like the installation of mobile telecommunications infrastructure on green roofs. The exposure of these green roofs to RF-EMF from mobile base stations illustrates the necessity for a deeper understanding of how digital technologies affect environmental sustainability, an area where IS research can offer valuable insights (EPRS, 2021).

As the field of IS continues to develop, DS has become a vital area of interest. While Green IT/IS established the foundation for understanding the role of IS in promoting sustainability, digital sustainability broadens this perspective to encompass the wider effects of digital technologies on the environment, society, and the economy (Monteiro et al., 2022). This shift highlights the increasing awareness that digital technologies are not merely tools for achieving sustainability; they are actively transforming the context in which sustainability initiatives occur (Monteiro et al., 2022). Furthermore, DS is gaining recognition as an important subject of study, not only within IS but also in related disciplines like organizational studies and technological entrepreneurship (George et al., 2020; Saba et al., 2018). This expanded viewpoint acknowledges that digital technologies are important for realizing the Sustainable Development Goals (SDGs) and are vital in fostering sustainable innovation (Monteiro et al., 2022; Watson et al., 2021; Watson et al., 2010). This development is especially pertinent in the examination of green roofs, where the relationship between digital technologies, such as mobile telecommunications, and environmental sustainability is particularly significant (EPRS, 2021). It is essential to understand how digital sustainability can be utilized to manage and reduce the risks linked to RF-EMF exposure on green roofs, as this knowledge is key to advancing both ecological and technological aspects of sustainability (Pophof et al., 2022).

Green IT and Green IS have been key topics in sustainability discussions within IS research (Kotlarsky et al., 2023; Wang et al., 2015; vom Brocke et al., 2013). Green IT focuses on minimizing the environmental impact of IT through energy-efficient practices, effective resource management, and responsible disposal methods (Thomas et al., 2015; Seidel et al., 2014; Molla, 2013). In contrast, Green IS emphasizes the configuration and application of IS to achieve broader environmental goals, such as facilitating decision-making that promotes sustainable outcomes (Leidner et al., 2022; Hedman & Henningsson, 2016; Loeser et al., 2017; Malhotra et al., 2013). These foundational ideas have shaped IS research for many years, but the growing complexity and interconnectivity of digital technologies have led scholars to call for a more comprehensive approach. For instance, Watson et al. (2010) suggest that the focus should extend beyond IT to encompass the wider implications of IS on sustainability. The shift from Green IT/IS to DS marks a significant evolution in how the IS field addresses sustainability. This evolution is especially relevant when examining the effects of RF-EMF exposure on green roofs. While green roofs provide ecological advantages, they are also at risk of increased RF-EMF exposure due to their closeness to mobile base stations (Recuero Virto et al., 2024). This dual aspect—both advantageous and vulnerable—necessitates a broader understanding of sustainability that integrates technological and environmental factors, as reflected in the concept of DS (Watson et al., 2010).

Three main themes have emerged regarding sustainability: the motivations for adopting sustainable solutions, the technologies and systems associated with Green IT/IS, and the strategies for implementing these solutions (Kotlarsky et al., 2023). These themes tackle the essential questions of why, what, and how technology can be utilized to meet sustainability objectives (Leidner et al., 2022; Hu et al., 2016; Coffey et al., 2013).

The technologies and systems associated with Green IT/IS play a crucial role in achieving sustainability goals. Research in this field has examined various tools and technologies that support environmental, economic, and social sustainability. For example, process virtualization technologies have been recognized as significant contributors to efficiency and environmental sustainability (Thomas et al., 2015). By converting physical processes into virtual formats, organizations can minimize their environmental impact while improving operational efficiency (Thomas et al., 2015). Additionally, IT reporting systems are essential for monitoring sustainability metrics and making the effects of sustainable technology more apparent to stakeholders (Bengtsson & Ågerfalk, 2011). Digital platforms and portals are also utilized to increase awareness of Green IT/IS initiatives, equipping organizations with the necessary tools to engage stakeholders and advocate for sustainability (Tim et al., 2020; Gholami et al., 2017a; Loock et al., 2013). Furthermore, decision support systems (DSS) and business intelligence (BI) systems are being increasingly employed to address sustainability risks and improve decision-making in areas like wildlife management and energy efficiency (Saba et al., 2024; Pan et al., 2020). Moreover, the introduction of mobile technologies, especially 5G, brings both challenges and opportunities for green roofs (ANSES, 2022). These technologies can enhance sustainability by facilitating better communication and data management, but they may also introduce risks related to increased RF-EMF exposure (ANSES, 2022). To understand and mitigate these risks, it is essential to integrate advanced technologies and systems that can monitor and manage the environmental effects of RF-EMFs on green roofs, aligning with the broader objectives of sustainable development (EPRS, 2021; Pophof et al., 2022).

Implementing Green IT/IS initiatives involves a thoughtful approach to design principles and frameworks that support institutions in their sustainability goals. For instance, sensemaking support systems and management analytics systems have been identified as key design principles for Green IT/IS (Pan et al., 2020; Seidel et al., 2017a; Seidel et al., 2017b). Another useful method is simulation modeling, which helps managers create sustainable production systems (Kurkalova & Carter, 2017). This technique enables institutions to predict the outcomes of various sustainability strategies, allowing for more informed decision-making (Bai & Sarkis, 2013). These frameworks offer practical tools for evaluating environmental costs and assessing the long-term benefits of investments in Green IT/IS (Bai & Sarkis, 2013; Melville, 2010). In the realm of green roofs, applying DS practices encompasses not only the design and upkeep of the roofs but also the incorporation of technologies that can reduce the potential adverse effects of RF-EMF exposure (EPRS, 2021). This necessitates a multidisciplinary approach that merges environmental science, information systems, and telecommunications technology, highlighting the intricate nature of DS (Monteiro et al., 2022).

The governance of DS initiatives brings forth distinct challenges and opportunities. Unlike conventional IT projects, DS efforts often demand a more entrepreneurial mindset (Kotlarsky et al., 2023), as sustainability is a relatively new focus for many organizations (George et al., 2020). The decentralized nature of DS initiatives, which typically emerge at the crossroads of digital/IT functions and sustainability efforts, requires a governance model that can adapt to the dynamic and cross-functional characteristics of these projects (Hu et al., 2016; Marais, 2014). To achieve effective governance in this setting, it is essential to integrate knowledge and expertise from various stakeholders—such as IT, sustainability, and business units—to ensure that DS initiatives are both thorough and aligned with the institution's broader objectives (Monteiro et al., 2022). In the case of green roofs exposed to RF-EMF, governance becomes important (EPRS, 2021). Successfully implementing sustainability measures on green roofs, particularly when considering the potential risks associated with RF-EMF exposure, requires well-coordinated governance strategies (Pophof et al., 2022). These strategies should not only highlight the environmental advantages of green roofs but also address potential risks to human health and biodiversity (Pophof et al., 2022; EPRS, 2021). Effective governance will ensure that these initiatives align with wider sustainability goals, such as those outlined in the UN SDGs, while remaining responsive to the evolving challenges introduced by new digital technologies (Monteiro et al., 2022).

Evaluating the performance of DS initiatives is important for understanding their effects and ensuring they effectively support sustainability objectives. Traditional performance metrics that emphasize short-term IT benefits fall short in capturing the wider, long-term impacts of DS initiatives (Thomas et al., 2015). For instance, when assessing the effects of RF-EMF exposure on green roofs, it is important to look at both the immediate environmental consequences and the long-term effects on human health, biodiversity, and urban ecosystems (EPRS, 2021). Therefore, performance assessment in DS should include a diverse set of indicators that reflect environmental, social, and economic outcomes (Leidner et al., 2022). These indicators could involve reductions in carbon emissions, enhancements in urban biodiversity, or increased resilience of ecosystems against technological disruptions (Watson et al., 2010). In the context of green roofs, performance metrics might also assess how effectively these structures reduce RF-EMF exposure and the related health benefits for city dwellers (EPRS, 2021). Additionally, the importance of digital tools in monitoring and evaluating these impacts is significant (Leidner et al., 2022). Advanced data analytics, machine learning, and other digital technologies provide robust methods for tracking sustainability performance in real-time, facilitating more responsive and informed decision-making (Watson et al., 2010). These tools are especially useful for green roofs, where ongoing monitoring of RF-EMF exposure and its impact on plant health and biodiversity is essential (Pophof et al., 2022).

DS ecosystems are becoming increasingly pertinent as institutions and external stakeholders join forces to promote sustainability initiatives (Gholami et al., 2017a; Bengtsson & Ågerfalk, 2011). These ecosystems consist of a variety of participants, including consultancies, technology providers, and regulatory bodies, all collaborating to advance sustainable practices through the creation and implementation of digital solutions (Tim et al., 2020; Dennehy et al., 2014). In the case of green roofs and RF-EMF exposure, the DS ecosystem may involve stakeholders such as urban planners, environmental scientists, telecommunications companies, and policymakers (EPRS, 2021). Each of these participants plays a role in ensuring that green roofs deliver ecological benefits while also addressing potential risks linked to RF-EMF exposure (Pophof et al., 2022). For example, technology providers could create sophisticated sensors and monitoring systems to measure RF-EMF levels on green roofs, while environmental scientists might evaluate how these levels affect plant health and biodiversity (Gomez et al., 2011). Policymakers could then utilize this information to shape regulations that safeguard both human health and the environment (EPRS, 2021). The interaction among these various stakeholders highlights the necessity of a well-coordinated DS ecosystem that harnesses the strengths of each participant to achieve shared sustainability objectives (Tim et al., 2020). As governments enforce stricter regulations concerning environmental protection and public health, the significance of DS ecosystems in promoting compliance and innovation becomes even more essential (ANSES, 2022). In the context of green roofs, these ecosystems can ensure that sustainability efforts not only meet regulatory standards but also adopt innovative strategies to tackle complex issues like RF-EMF exposure (Pophof et al., 2022).

2.2 Theoretical Development

Kotlarsky et al. (2023) have identified three main sustainability outcomes: environmental, social, and economic sustainability. Among these, environmental sustainability has garnered the most attention. This aspect focuses on minimizing the use of natural resources and adopting practices that enhance the planet's health and resilience (Berkowitz et al., 2019; Melville, 2010). The primary aim is to reduce greenhouse gas emissions, prioritize renewable resources, and maintain the environment's ability to support life (Ekins, 2011). Research in this field often centers on improving products, services, and practices that meet societal and environmental responsibilities (Gautier & Bonneveux, 2021), such as protecting biodiversity and ensuring the sustainable management of natural resources for future generations (Morelli, 2011).

Social sustainability, another outcome, emphasizes the importance of fostering healthy social development (Corbett et al., 2023) by strengthening civil society and ensuring that present needs are met without jeopardizing the well-being of future generations (Vallance et al., 2011). Examples include leveraging IS to improve healthcare access in rural areas and promoting sustainable social change in developing regions through entrepreneurship and e-commerce facilitated by digital technologies (Tim et al., 2020).

Economic sustainability, the third key outcome, involves practices that foster long-term economic growth while safeguarding environmental resources, enhancing living standards, and strengthening social institutions (Spangenberg, 2005). This outcome is frequently pursued through the incorporation of Green IT within organizations, where technology-driven solutions are utilized to lower energy expenses and encourage sustainable business practices (Cooper & Molla, 2017; Thomas et al., 2015).

A comprehensive view of sustainability outcomes is important for grasping the intricate relationships between digital technologies and environmental sustainability, especially regarding green roofs subjected to RF-EMF. In this context, our research proposes key connections between public perceptions and the dual goals of promoting digital technologies while ensuring environmental sustainability. For instance, we suggest that participants will place a higher priority on human health than on plant health when evaluating the risks associated with RF-EMF exposure from green roofs, reflecting the broader economic and ethical considerations tied to digital sustainability (Dao et al., 2011). Furthermore, we investigate how cognitive, emotional, and moral perceptions shape public risk evaluations, drawing on insights from the IS literature about the influence of perceptions on technology adoption and environmental risk management (Brosch & Steg, 2021; Freudenstein et al., 2015).

This study contributes incrementally by examining the interaction between green roofs and RF-EMF exposure, an underexplored issue at the intersection of urban sustainability and digital health. While much research has explored the benefits of green roofs or the risks of RF-EMF exposure separately, this paper offers a novel contribution by investigating their potential conflict and its implications for future urban planning and policy. Our research explores the intricate relationships between green roofs and mobile radiation exposure, situating these issues within the broader context of IS research and its evolving focus on sustainability. Particularly, we adopt a holistic perspective that integrates technological, ethical, and social dimensions of sustainability, consistent with the vision of DS. This approach aligns with the broader IS literature, which emphasizes leveraging technology to minimize ecological impacts while fostering sustainable development (Jenkin et al., 2011). Furthermore, the ethical responsibilities of the IT sector, as underscored by Dennehy et al. (2023), highlight the importance of balancing technological advancements with environmental and societal goals (Baskerville et al., 2019; Gholami et al., 2017b). These interconnected priorities frame our study, which examines public perceptions and preferences related to the trade-offs between digital technologies and environmental sustainability. This leads us to propose several hypotheses that reflect the dynamic interplay between public valuation, ethical considerations, and sustainability goals.

The first relationship we explore is the prioritization of use values (human health and recreational benefits) over non-use values (plant health). Hypothesis 1 builds on the total economic value framework (Richardson & Loomis, 2009), which distinguishes between direct benefits (use values) and intrinsic benefits (non-use values). In the context of RF-EMF exposure on green roofs, we posit that participants will attribute higher value to the immediate and tangible benefits of human health compared to the less direct benefits of plant health. This preference is consistent with IS research's emphasis on environmental sustainability, where addressing greenhouse gas emissions and prioritizing renewable resources are central goals (Ekins, 2011; Melville, 2010). Furthermore, prioritizing use values aligns with societal preferences for maintaining living standards and ensuring economic viability, which frequently favors human-centric outcomes (Dao et al., 2011).

Hypothesis 1: Participants will attribute higher valuations to use values (human health and recreational values) than to non-use values (plant health).

Given the increasing public concern over the potential health risks associated with mobile radiation, particularly with the advent of 5G technology, Hypothesis 1 posits that individuals will prioritize funding for human health research over plant health research. This aligns with broader policy challenges where health-related issues often dominate public discourse and funding agendas, especially in regions with higher exposure to mobile technologies. For example, in densely populated urban areas, where green roofs serve not only as environmental assets but also as spaces for human well-being, public health concerns about the long-term impacts of RF-EMF on residents are more pressing. Therefore, understanding the preference for human health over plant health in the allocation of research funds becomes important for policymakers aiming to balance urban sustainability goals with public health priorities.

Expanding on this, we consider the ethical implications of research methodologies used to assess the effects of RF-EMF exposure. As sustainability research increasingly addresses non-human subjects, ethical considerations play a pivotal role. While the ethical treatment of animals has long been debated, these concerns are now extending to plant life (Deckers, 2012). Participants are likely to favor computer simulations as a preferred research method due to their non-invasive nature, which avoids harm and circumvents ethical dilemmas related to consent. This preference reflects a broader societal trend toward minimizing harm in research and aligns with IS research’s emphasis on fostering healthy social growth and respecting the well-being of all forms of life (Vallance et al., 2011). This ethical dimension leads us to Hypothesis 2.

Hypothesis 2: Participants will prefer computer simulations over laboratory and field experiments from an ethical perspective.

Shifting to the financial dimensions of public support, Hypothesis 3 focuses on the role of economic sustainability in influencing WTP. As green roof initiatives introduce financial burdens, it becomes crucial to assess their economic feasibility. Economic sustainability emphasizes the balance between fostering long-term growth, preserving resources, and maintaining living standards (Spangenberg, 2005). When costs rise, public WTP is expected to decrease, highlighting the importance of economically viable strategies to ensure broad support for green infrastructure projects. This understanding underscores the need for cost-effective, sound initiatives that contribute to long-term sustainability.

Hypothesis 3: As the payment required for funding green roof initiatives increases, there will be a decrease in the willingness to pay (WTP) among the public.

Hypothesis 3 suggests that as the cost of funding research on the effects of RF-EMFs increases, public WTP will decrease, reflecting economic constraints and the perceived fairness of the burden. In light of regional policy differences, this hypothesis can be contextualized by the financial realities of different regions. For instance, urban populations with higher living costs and greater exposure to mobile technologies may exhibit a lower WTP due to competing financial demands. In contrast, in less urbanized areas, where the prevalence of mobile radiation may be lower, the public may be more willing to support initiatives to protect plant health, as the immediate health risks may not be as pronounced. Understanding these regional variations in WTP can help inform policymakers about the need for differentiated funding strategies based on regional economic conditions and environmental priorities.

In addition to financial considerations, perceptions of risk play an important role in shaping public attitudes. Hypothesis 4 highlights the dominance of cognitive perceptions in assessing risks associated with RF-EMFs, particularly in human exposure scenarios. Cognitive perceptions, rooted in rational analysis, are essential for informed decision-making about environmental risks (Freudenstein et al., 2015). Public assessments are likely to prioritize cognitive evaluations when human health is at stake, as these contexts often demand rational, evidence-based judgments. In scenarios of human exposure to RF-EMFs, participants are expected to rely heavily on cognitive perceptions, given the direct and personal nature of the potential harm (Freudenstein et al., 2015).

Hypothesis 4: Cognitive perceptions will play a dominant role in explaining risk perceptions associated with exposed organisms, especially when the organism is a human.

Complementing cognitive perceptions, Hypothesis 5 explores the significance of affective perceptions—emotional responses to environmental risks—particularly in the context of plant exposure. Emotional connections to nature often influence environmental risk perceptions and drive sustainable action (Brosch & Steg, 2021). The affective dimension of sustainability is crucial for engaging public support, as fostering emotional ties to nature strengthens the connection to sustainability initiatives (Home et al., 2009). When it comes to plant health and exposure to RF-EMFs, participants are likely to demonstrate heightened concern due to these emotional bonds.

Hypothesis 5: Affective perceptions will be significant in explaining risk perceptions concerning plant exposure to RF-EMFs.

Finally, Hypothesis 6 investigates the role of moral perceptions in shaping risk perceptions, particularly among younger individuals. Moral perceptions encompass concerns about fairness, harm, consent, and integrity, all of which are integral to public evaluations of sustainability challenges (Li et al., 2022). Young people, often more attuned to social justice and environmental ethics, are expected to exhibit strong moral considerations in evaluating risks linked to technological advancements such as mobile radiation exposure (Haidt & Joseph, 2004). These moral dimensions are likely to significantly influence their attitudes, reinforcing the need to integrate ethical considerations into sustainability efforts within IS research.

Hypothesis 6: Moral perceptions will play a role in explaining risk perceptions associated with exposed organisms, particularly among young people.

The framework's emphasis on stakeholder engagement is also mirrored in our study, particularly in how we examine public perceptions and their influence on the adoption of green roofs in the presence of mobile radiation. Engaging stakeholders, including the public, is essential for the successful implementation of IS-driven sustainability initiatives, as demonstrated in the literature on Green IS and sustainability transformations (Corbett & Mellouli, 2017; Seidel et al., 2014). Additionally, by focusing on the economic dimension of sustainability, our research seeks to contribute to a nuanced understanding of how economic viability interacts with environmental and social factors. This insight is critical for policymakers and practitioners who aim to develop economically sustainable models for green infrastructure, reflecting the broader discourse on economic sustainability within the IS field (Melville, 2010).

3 Methodology

3.1 Survey Research Methodology

Survey[1] research is particularly effective when the central questions of interest involve understanding "what is happening" and "how and why it is happening" in natural settings, which aligns well with our study's goals of examining public perceptions and decision-making processes regarding green roofs and mobile radiation exposure (Pinsonneault & Kraemer, 1993). This methodology is especially valuable when the objective is to gather data that can be generalized across a broader population, providing insights into patterns of behavior and perception that might not be apparent through more qualitative methods (Mohajan, 2020).

By utilizing this approach, we can collect quantitative data from a large and diverse group, making it possible to identify significant trends and relationships that can inform both theory and practice (Motiwalla et al., 2019). Given the complexity and real-world context of our study - where digital technologies intersect with environmental sustainability - this method is robust for exploring these dynamics across various demographics (Acquier et al., 2011; Pinsonneault & Kraemer, 1993). It is particularly pertinent in IS research when studying phenomena that are contemporary and situated in natural environments, as is the case with our focus on urban green roofs and RF-EMF exposure. Furthermore, this method is instrumental in capturing a broad spectrum of responses and perceptions, which is essential when the aim is to develop policies and practices grounded in empirical evidence. Thus, the use of a survey-based method is suitable for our research objectives, enabling us to systematically analyze public perceptions and the potential trade-offs involved in integrating green roofs with modern technological infrastructure.

A total of 276 individuals participated in the survey, with 169 of the responses being fully completed (see Table 5). The survey was structured into five distinct sections: 1) an introduction; 2) respondent profile information; 3) selections of funding options related to the effects of RF-EMFs on plants in green roofs; 4) perceptions of the effects of EMFs on green roofs; and 5) concluding remarks. The final version of the survey was developed following consultations with researchers from various disciplines and through cognitive one-on-one interviews with individuals. These steps ensured that the survey was both comprehensive and accessible. In the introductory notes, participants were informed that no specific prior knowledge was required to respond to the questions. Additionally, the survey's topic was intentionally omitted in the introduction to prevent self-selection bias, which could occur if respondents chose not to participate based on the topic. This approach helped to minimize the risk of skewing the data. To ensure the quality of responses, particularly in the online version of the survey, only one question was displayed per page. This design feature aimed to reduce the likelihood of "speeding" through the survey, where participants might quickly answer without due consideration. Our target population primarily consisted of university students in the Paris Region (Île de France), an area characterized by high urban density. Given the prevalence of green roofs in this region, these individuals are particularly relevant to the study. Indeed, we specifically focus on university students in the Paris region, which is a highly relevant context for examining public attitudes towards emerging technologies like 5G. Indeed, Paris is a major urban center at the forefront of technological advancements, particularly 5G. For example, there are currently 26 experimental licenses for 5G to explore new technical and economic models in Île de France for the 3,5 GHz band alone (ARCEP, 2025). University students are often early adopters of new technologies and are highly engaged with issues related to both technological advancements and sustainability. Shahzad et al. (2023) highlight that this demographic is more likely to embrace new technologies like 5G and is also particularly attuned to the environmental implications of such technologies. Their awareness of sustainability and tech-savviness makes them an ideal group for studying attitudes toward mobile

[1] Link to the survey: https://devinci-my.sharepoint.com/personal/peter_saba_devinci_fr/_layouts/15/guestaccess.aspx?share=ESV36OilQDpNqza1tnyI-UUBxlfHXsMbdtZKg-BaF79Asw&e=ZU65Wg

radiation and its environmental impacts. While this focus limits the generalizability of the findings, it provides valuable insights into the relationship between emerging technologies and sustainability, which can be further explored in future studies with more diverse samples.

In the first section, participants were provided with an overview of the survey's purpose and a brief background on the topic. The second section gathered demographic information, including age, gender, income, education, occupation, and location. This data allowed us to compare our sample with a representative sample of the French population, using national statistics on gender, age, and socioeconomic categories (as detailed in Table A.1 of Appendix A). Additionally, in this section, respondents were asked to confirm their willingness to complete the survey, thereby obtaining explicit consent, even though it was not strictly necessary due to the anonymous nature of the data collection. The survey was designed to provide participants with clear, concise information about their role in urban sustainability and environmental benefits. To ensure that unfamiliarity did not unduly influence responses, follow-up questions were included, asking participants to rate the importance of three key characteristics in their decision-making process: the value of the research focus (e.g., human health vs. plant health), the environment in which the research takes place (e.g., field vs. laboratory settings), and the monetary contribution required for the research. A low score attributed by respondents to these factors could reflect a high influence of their lack of knowledge about green roofs since these factors were selected after consultations with experts and individuals familiar with green roofs. This follow-up together with the analysis of perceptions helps control for the lack of familiarity with green roofs.

3.2 Funding Options on the Effects of Mobile Radiation on Plants in Green Roofs

In the third part of our survey, participants were asked to choose among various funding options concerning research on the effects of RF-EMF on plants in green roofs. Before governments commit financially to such initiatives, it is important to assess the WTP of the population - who are the ultimate beneficiaries - within a cost-benefit framework. To accurately estimate individual preferences in this context, we employed the Discrete Choice Experiment (DCE) method, which is well-regarded for its ability to capture a wealth of information regarding a range of policy options under consideration (Carson & Czajkowski, 2014).

A critical aspect of our approach was the selection of the payment vehicle, as it can significantly influence respondents' preferences, including their WTP for the proposed research. To ensure consistency and relevance, we opted for a taxation-based survey, a common approach in environmental economics when assessing public goods (Cunha-e-Sá et al., 2023; Guo et al., 2014; Ivehammar, 2009; Wiser, 2007). Specifically, we informed participants that all scenarios would involve an annual surcharge on their telecom bills, applicable to all mobile phone users. This consistent payment vehicle helped standardize responses and facilitated more accurate comparisons of WTP across different scenarios.

Within the DCE, participants were first introduced to the three key attributes that would define the scope of research on the effects of EMFs, along with three possible values for each attribute (see Table 1). We also questioned respondents on the significance they placed on each attribute (question 16), recognizing that a low rating of any attribute could potentially introduce bias into the experiment (a phenomenon known as attribute non-attendance (Sèbe et al., 2019).

The first attribute in our DCE analysis focused on the values that should be prioritized in the research. We based this on the widely used total economic value framework for environmental valuation, which, as already explained, differentiates between use values - such as direct, ecological, and cultural values - and non-use values, like intrinsic values. Prior research indicates that non-use values typically receive lower valuations. This is the reason why we hypothesized that participants would assign higher valuations to use values (such as human health and recreational benefits) than to non-use values (such as plant health) in the context of EMF research (see Hypothesis 1).

Table 1. Attributes and Values for DCE on Funding Research into EMF Effects on Green Roofs

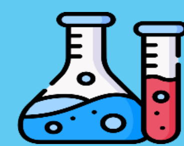
Attributes	Values	Explanation
1. THE VALUES THAT SHOULD BE THE FOCUS OF THE RESEARCH	***plant health***	• focuses on the health of plants
	recreational values	• focuses primarily on the health of plants, but also in relation to human wellbeing (for example, with green roofs that people can visit and enjoy)
	human health	• focuses primarily on the impact on human health
2. THE TYPE OF ENVIRONMENT FOR THE RESEARCH	***in a laboratory***	• with potential injury and no consent from the plant • controlled conditions, but difficult to generalize
	with a computer simulation	• without injury, no need of consent from the plant • cost-effective, but computer models are always different from real organisms
	in a green roof	• with potential injury and no consent from the plant • real conditions but difficult to set up
3. THE AMOUNT YOU WOULD ALLOCATE FOR THE RESEARCH THROUGH TAXATION	***5*** ***25*** ***50***	• contribution in euros per year that you would be willing to pay for the research

The second attribute in the DCE focused on the research environment. As already stated, there are increasing demands and regulations on the ethics of animal-based research. Ethical considerations in research have primarily centered on animals, but can be extended to plant research. Therefore, we hypothesized that participants would favor computer simulations over laboratory and field experiments from an ethical standpoint (see Hypothesis 2), as simulations do not cause harm to plants and do not require consent. The third DCE attribute determined the amount of funding participants were willing to allocate to the research based on values typically used in environmental valuation studies. Hence, we anticipated a negative correlation between the required payment and participants' WTP, aligning with our expectation that higher costs would reduce WTP (see Hypothesis 3).

The three attributes chosen for this study - plant health, human health, and research environment - were selected to reflect the key concerns regarding mobile radiation and sustainability. They were chosen following consultations with experts from various disciplines and cognitive interviews conducted with individuals proxying the general public. Comparing human health versus plant health was considered fundamental by scientists since the bulk of the public funding for research on the effects of RF-EMF targets human health whereas research on plant health is extremely scarce (Karipidis et al., 2021). In the same vein, most of the public funds are allocated to laboratory studies, and computer simulations, since their primary role is to extrapolate the findings on the effects of RF-EMF on mammals such as rats to human health. However, many results from analyses under laboratory conditions and from simulations cannot be extrapolated to environmental conditions where multiple stressors co-occur to derive implications for wildlife (Czerwiński et al., 2023; Malkemper et al., 2018). Some rare field experiments provide preliminary evidence of irreversible exposure effects for certain wild plant species (Czerwiński et al., 2023). Hence, more data and high-quality analyses mimicking field-realistic exposure are needed to document the effects of electromagnetic fields on wildlife (Kaur et al., 2021; Vanbergen et al., 2019; Goudeseune et al., 2018). The underlying question is whether policymakers are rightly interpreting public perceptions as merely concerned with the effects of RF-EMF on human health, or whether they have a more balanced attitude regarding the impacts of exposure on plants. We aimed for a balance between simplicity and relevance, acknowledging that public preferences may be more complex, but these attributes effectively capture the primary factors influencing WTP.

For each combination of attributes and their corresponding values in Table 1, an alternative scenario was created. To avoid overwhelming respondents, each choice set presented three alternatives (see Table 2). The first two alternatives varied in at least one attribute, while the third alternative represented the status quo, involving no additional action or funding for research on the effects of RF-EMF on plants on green roofs. Participants were then required to select one of the three presented alternatives.

Table 2. Example of a Choice Set

Which would be your preferred option for funding the research on the effects of electromagnetic fields on plants in green roofs?	OPTION 1	OPTION 2	OPTION 3
1. **The values that should be the focus of the research**	 ***plant health***	 ***recreational values***	**Neither option (status quo)**
2. **The type of environment for the research**	 ***with a computer simulation***	 ***in a laboratory***	
3. **The amount you would allocate for the research through taxation**	 ***25 euros***	 ***50 euros***	
Choice	Option 1	Option 2	Neither option (status quo)

The total number of choice sets (18) was deliberately set to be several times larger than the minimum required size to ensure sufficient degrees of freedom and to gather more comprehensive information on individual preferences. An explicit heterogeneous design was implemented by dividing the total number of generated choice sets into three distinct blocks (Block A, Block B, and Block C), with each block containing six choice sets. Respondents were randomly assigned to one of these three blocks, allowing them to evaluate different versions of the DCE (Frings et al., 2023; Cunha-e-Sá et al., 2023).

To generate the scenarios, non-informative priors were used to determine the expected choice probabilities, as informative priors can quickly become inefficient if the true value significantly deviates from the prior. This approach allowed for greater flexibility and accuracy in capturing respondent preferences. Follow-up questions were included at the end of the second part of the survey to address some core aspects of the DCE analysis (Cunha-e-Sá et al., 2023; Frings et al., 2023). First, it was essential to identify "protesters" - participants who frequently chose the status quo option due to rejecting some aspect of the proposed framework (as indicated by the first five choices in question 17, which identify ‘protest zeros’). These respondents needed to be distinguished from those providing responses that reflect genuine preferences, which could indicate ‘valid zeros’, such as cases where participants could not afford the proposed price or felt that society has more pressing issues to address (identified by the last five choices in question 17. Some researchers advocate for excluding protesters from the analysis to avoid bias in estimates, while others argue that including them provides conservative estimates for WTP.

Additionally, to gain further insights into participants’ views, a complementary question on fairness was included to assess whether they believed the costs should be borne by mobile operators and other technological companies (question 18) (Rakotonarivo et al., 2017). The plausibility of the survey scenario, particularly the payment vehicle, was also evaluated. Participants were asked how plausible they considered a mandatory annual tax per mobile telecom user, collected by the mobile operator and administered by the government, to fund research on the effects of RF-EMF on plants in green roofs in the future (question 19) (Frings et al., 2023; Rakotonarivo et al., 2017). Following this, the policy consequentiality of the DCE exercise was tested - specifically, how much respondents believed that the outcome would influence policy decisions (question 20) (Frings et al., 2023). To reinforce this, a statement was included in the survey's introduction informing participants that the results of the research would be shared with policymakers and other stakeholders (government, regulatory authorities, the private sector, and NGOs) to inform policy decisions. We also assessed whether respondents trusted the institution responsible for managing the funds (question 21) (Cunha-e-Sá et al., 2023; Rakotonarivo et al., 2017). The introductory notes emphasized that there were no wrong answers and that it was important for participants to respond to the questionnaire as honestly as possible (Frings et al., 2023).

Questions 19, 20, and 21 aimed to determine the extent to which participants believed that the scenarios presented in the survey would materialize, as this belief significantly affects WTP estimates. This touches on the concept of incentive compatibility, where participants are motivated to reveal their true preferences (Wiser, 2007). Additionally, payment consequentiality - where participants believe they are choosing an option they will have to pay for - is essential in DCEs. In this survey, payment consequentiality was ensured by making the payment mandatory for all participants, thus preventing free riding (Johnson et al., 2017). However, it is worth noting that voluntary payments can also be effective policy tools, as they tend to be more socially acceptable than mandatory schemes, especially in contexts of high inflation (Do et al., 2022).

3.3 Perceptions on the Effects of RF-EMF on Plants, Fungi, and Animals

The fourth part of the survey focused on participants' perceptions regarding the effects of RF-EMFs on plants in green roofs. The primary objective of this section was to gather evidence related to risk perception that could help explain the funding choices made in the third part of the survey (De Groot & Steg, 2010). To facilitate visual comparison, we presented participants with three images, each depicting different scenarios on a rooftop: a tree, a person, and a tree shielding a person, all exposed to RF-EMF. The images were designed using simple icons to ensure clarity and ease of comparison.

Participants were then asked to express their feelings (affective perception) towards each image, as well as their moral concerns (moral perception). Additionally, they were asked to evaluate how severe (cognitive perception) and how dangerous (risk perception) they perceived the effects of EMFs on the depicted organisms to be. In alignment with Freudenstein et al. (2015) research on the significance of cognitive perceptions in the context of human exposure, we hypothesized that cognitive perceptions would play a dominant role in explaining risk perceptions, particularly when the exposed organism is a human (see Hypothesis 4). Furthermore, affective reactions - especially those connected to nature - are recognized as key predictors of environmental risk perceptions and critical factors in motivating action. Therefore, we expected these affective perceptions to be significant when assessing participants' perceptions of EMF exposure to plants (see Hypothesis 5).

While cognitive and affective perceptions were expected to be more influential, we also anticipated that moral perceptions would play a role in shaping risk perceptions related to exposed organisms, particularly among younger participants (see Hypothesis 6). Moral perceptions are known to be vital in influencing risk perceptions and driving pro-environmental behavior among young adults.

3.4 Econometric Analysis of Survey Data: Evaluating Funding Options

The DCE model is used to uncover the preferences of survey respondents regarding their preferred funding options for research on the effects of RF-EMF on plants on green roofs. These preferences are modeled using a random utility framework, which allows for the systematic analysis of the factors that influence respondents' choices.

$$u_{ijt} = \beta_i' x_{ijt} + \varepsilon_{ijt} \quad (1)$$

where *i=1,…,N* indicates the respondent with *N*=169 (completed surveys), *j=1,..J* denotes the alternative with *J*=3, *t=1,…,T* defines the choice set with *T*=6, x_{ijt} is a vector characterizing the *K*=3 attributes related to individual *i*, alternative *j*, and choice occasion *t*, β_i is a vector defining individual-specific coefficients of those *K* attributes, and ε_{ijt} stands for the stochastic component term that captures the unobserved utility. A normal distribution is assumed for the β_i coefficients associated with the non-monetary attributes. The individual *i* chooses the alternative *j* that maximizes its perceived utility considering observed and unobserved preferences such that $u_{ijt} = u_{ilt}\ \forall j \neq l$.

The estimated model is based on a mixed logit specification which allows for control for the impact of individual heterogeneity in preferences, and relaxes the assumption of independence of irrelevant alternatives (IIA) (Revelt & Train, 1998).[2] This model can control for correlated random parameters which can capture behavioral features and thus avoid biased estimates (Hole & Kolstad, 2011). The unconditional probability of the observed sequences of alternatives during the *T* periods of respondent *i* is given by the following equation:

$$P_i(\theta) = \int \prod_{t=1}^{T=6} \frac{\exp(\beta_i' x_{ijt})}{\sum_{j=1}^{J=3} \exp(\beta_i' x_{ijt})} f(\beta|\theta) d\beta \qquad (2)$$

where $f(\beta|\theta)$ is the density for β and θ are the distribution parameters. The parameters are estimated by maximizing the simulated log-likelihood (SLL) function following Train (2009):

$$SLL(\theta) = \sum_{i=1}^{N} ln \left\{ \frac{1}{R} \sum_{r=1}^{R} \prod_{t=1}^{T=6} \prod_{j=1}^{J=3} \left[\frac{\exp(\beta_i^{[r]\prime} x_{ijt})}{\sum_{j=1}^{J=3} \exp(\beta_i^{[r]\prime} x_{ijt})} \right]^{y_{ijt}} \right\} \qquad (3)$$

where *R* are the number of random draws of the vector of parameters $\beta^{[r]}$, $\beta_i^{[r]}$ is the r-th draw of the respondent i according to the density $f(\beta|\theta)$, and y_{ijt} = 1 when the respondent selected the alternative *j* for the choice set *t*, and 0 otherwise.[3]

WTP in the context of DCE can be estimated as a ratio between the coefficient of the attribute and that of the price, that is, the ratio between two randomly distributed factors which can lead to skewed estimates and undefined moments. There are several ways of addressing this problem (Hole & Kolstad, 2011). First, the price coefficient can be specified to be fixed, but this assumes that there is no individual heterogeneity concerning price. Second, the price coefficient can be specified to be log-normally distributed, avoiding undefined moments. Third, the model can be estimated in the WTP space, instead of the preference space, whereby the model coefficients represent WTP measures. While models in the preference space allow them to fit the data better, models in the WTP space are characterized by more accurate WTP measures (Train & Weeks, 2005). Equation (1) can be rearranged in the following way to work in the WTP space:

$$u_{ijt} = \lambda_i(\beta_i' z_{ijt} + p_{ijt}) + \varepsilon_{ijt} \qquad (4)$$

where z_{ijt} is a vector characterizing non-monetary attributes related to individual *i*, alternative *j*, and choice occasion *t*, that is, the values that should be the focus of the research and the type of environment for the research, p_{ijt} is a vector denoting the amount that the participant would be willing to allocate for the research through taxation, γ_i is a vector defining individual-specific coefficients of non-monetary attributes with $\gamma_i = \beta_i^*/\lambda_i$, β_i^* is the vector of coefficients of the non-monetary attributes in x_{ijt}, and λ_i is the parameter of the monetary variable for the participant *i*.[4]

3.5 Econometric Analysis of Perception Data: Understanding Survey Respondents' Views

To empirically investigate the determinants risk perception concerning the effects of RF-EMF, a set of linear regressions were run, where the response is modeled as a linear function of the predictor variables:

$$y_i = \gamma_0 + \beta' x_i + \pi' z_i + \varepsilon_i \qquad (5)$$

where the subscript $i = 1, 2, \cdots, N$ indicates the respondent, y_i designates risk perception, x_i is a vector of explanatory variables that allows the analysis of risk perception determinants' proxies associated with hypotheses 4 to 6, z_i is another vector of explanatory variables that enables control for some features that

[2] According to the IIA assumption, for instance, when respondents select among a set of alternatives, their odds of choosing alternative 1 over 2 should not depend on the absence or presence of alternative 3. Relaxing this assumption allows for more flexible substitution patterns between alternatives and more accurate predictions.
[3] The model is estimated through stata sofware (Hole, 2007a).
[4] The model is estimated through stata sofware (Hole, 2007a).

may be important when defining risk perception determinants such as the respondents' age or sex, γ_0 is a scalar parameter, β and π are vector parameters, and ε_i is an error term. This standard regression technique produces Ordinary Least Squares (OLS) estimations of the parameters $\hat{\beta}$ and $\hat{\pi}$ (Wooldridge, 2019; Greene, 2018).

3.6 Respondents' Characteristics

The data collection took place between January 25th and March 1st, 2024, with participants being recruited primarily through university students in the Paris Region (Île de France). These students were organized into groups of five and were instructed not only to complete the survey themselves but also to gather responses from a diverse cross-section of the population. This approach aimed to capture a range of perspectives, ensuring representation across different sexes, socio-professional categories, and age groups (both below and above 45 years old). Table 3 presents some of the key characteristics of our survey population. As anticipated, the sample shows an overrepresentation of students aged 18 to 24 years, while workers, retirees, and individuals over 55 are underrepresented. The demographic data on income and education levels aligns closely with the national statistics referenced in Table A.2, confirming the reliability of our sample. Regarding the residential distribution of respondents, nearly half reside in suburban areas, 30% in large cities, 12% in small towns, and 7% in villages. Awareness and engagement with green roofs varied among respondents: approximately 50% had heard of green roofs, 10% had visited one, and 11% reported having a green roof on their building or in a nearby structure (see Table 4).

Table 3. Descriptive Statistics: Comparison with the French population

Respondent	Sample (%)	French population (%)
Gender		
Females	46	52
Males	54	48
Age		
18-24	57	11
25-34	9	16
35-44	7	18
45-54	14	18
55-64	8	15
65+	4	22
Socio professional category (detailed)		
Business Manager / Independent (Farmer + Artisan, Merchants + Business Manager)	8	5
Managerial staff	13	10
Intermediate professions	5	15
Employees	13	17
Workers	1	13
Retired	3	28
Student	53	4
Other inactive	0	8

Note: Data extracted from completed surveys.

Table 4. Descriptive Statistics: Green Roofs

Respondent	Sample (%)
Had you heard about green roofs before this survey?	
Yes	31,36
No	45,56
Somewhat	23,08
Have you visited a green roof?	
Yes	10,06
No	89,94
Do you have a green roof in your building or in a building nearby?	
Yes	11,24
No	86,39
Other/no answer	2,37

Note: Data extracted from completed surveys.

The proportion of incomplete surveys observed in this study is within the expected range for survey-based research (see, for example, Frings et al., 2023). However, since this proportion is not attributed to any quota limitations, it is possible that our results may not fully capture more conservative perspectives on the topic. Respondents could not drop once they had seen the topic due to lack of interest or rejection since the first online page of the survey was explicitly designed without any precise information other than sharing that it was a research survey. The large number of incomplete surveys may be partly explained by the time to complete the survey. The estimated value was 10 minutes, and this was shared with respondents before they completed the survey. The median time to complete the survey was 14 minutes. Additionally, "speeders" were identified by isolating participants who completed the survey in less than 25% of the median response time, which equated to 3.5 minutes or less. This resulted in the identification of 4 participants who met this criterion.

Moreover, there were 6 respondents who consistently assigned low ratings to each of the three attributes, which has the potential to introduce bias into the analysis (as indicated in question 16). Protesters were identified as participants who systematically chose the status quo option across all six choice sets and selected 'protest zeros' (as indicated in question 17). Among the 7 respondents who always selected the status quo, 4 were identified as 'protesters. In addition, we observed varying levels of concern among respondents on specific issues: 7 participants expressed strong concerns about fairness (question 18), 26 questioned the plausibility of the scenarios presented (question 19), 9 doubted the consequentiality of the choices (question 20), and 45 expressed distrust in the institutions responsible for managing the funds (question 21). Given that these factors, detailed in Table 5, could significantly impact the estimates, they were incorporated into our econometric strategy.

Typically, respondents mistrusting institutions choose the status quo, that is, to reject the different scenarios that are presented to them, with a higher probability. This is particularly the case when the payment vehicle is a mandatory tax like in our paper, leading to a bias with an underestimation of the WTP estimates. Given a lack of trust in politicians and institutions, respondents may fear that the payment is not allocated to the foreseen recipient. Overall, DCE experiments are regularly associated with very large mistrust perceptions by the population concerning the management of funds by government institutions (Cunha-e-Sá et al., 2023). This issue can be addressed either by performing robustness tests as in this paper or, by developing research on additional samples with alternative payment vehicles such as crowdfunding mechanisms.

Table 5. Data Characterization

	Number of surveys	**% of surveys**
Total surveys	276	100
Not completed surveys	97	35,1
Completed surveys	169	64,9
Speeders	4	1,4
Robustness factors		
Low sensitivity to attributes	6	2,1
Protesters	4	1,4
Fairness concerns	7	2,5
Non-plausibility	26	9,4
Non-consequentiality	9	3,2
Contesting institutions	45	16,3

4 Results

4.1 Analysis of Funding Options

Table 6 presents the econometric results concerning individual preferences for funding research on the effects of RF-EMF on plants in green roofs. Models 1 through 4 were derived using the mixed logit methodology specified in equation (1) (preference space), while Model 5 was obtained using the mixed logit methodology as outlined in equation (4) ([WTP] space). In Model 1, the price coefficient, along with the other explanatory variable coefficients, is assumed to be normally distributed. Model 2 differs by fixing the price coefficient, thereby assuming no individual heterogeneity with respect to this factor. Model 3 builds on Model 1 by introducing correlated random parameters, while Model 4 extends Model 2 by also incorporating correlated random parameters. In Model 5, the price coefficient is lognormally distributed, whereas the other explanatory variable coefficients maintain a normal distribution.

Table 6 details the estimated values of the parameters associated with the explanatory variables listed in the first column. It also provides key information about each regression, including the number of observations (#Obs.), and the number of individuals (#Individuals). Additionally, the table includes several goodness-of-fit measures: the final log-likelihood (Log-like.), the Akaike Information Criterion (AIC), and the Bayesian Information Criterion (BIC). Furthermore, a variable reflecting a respondent preference for no action on funding research into the effects of RF-EMFs on plants in green roofs (status quo) is also included. Table A.3 in Appendix A provides more detailed information including the standard deviations associated with the explanatory variables, correlated random parameters, the number of draws (#Draws), the number of estimations (#Estimations), and a chi-squared (Chi2) test for the joint significance of the coefficients for standard deviations.

Table 6. Mixed Logit Analysis of Individual Preferences for Funding Research on Electromagnetic Field Effects on Green Roof Plants

	Preference space				**WTP space**
Explanatory variables COEFFICIENTS	Model 1	Model 2	Model 3	Model 4	Model 5
Plants health	0,365***	0,342***	0,412***	0,350***	41,06**
Human health	0,783***	0,759***	0,849***	0,766***	96,29**
Laboratory	-0,194	-0,172	-0,230	-0,223*	-11,91
Computer	-0,143	-0,129	-0,169	-0,181	-15,25
Payment	-0,010***	-0,009***	-0,012***	-0,010***	-4,98***
Status quo	-2,480***	-2,444***	-2,570***	-2,538***	-491,64***
#Obs	2 970	2 970	2 970	2 970	2 970
#Individuals	165	165	165	165	165
Log-like.	-878,43	-879,27	-869,40	-872,47	-874,52
AIC	1780,86	1780,54	1792,81	1786,95	1773,05
BIC	1852,82	1846,50	1954,71	1912,87	1845,01

Note: The estimated values of the parameters associated with the explanatory variables are listed in the first column. Information is available on the number of observations (#Obs.), the number of individuals (#Individuals), and several goodness-of-fit measures: Log-like., AIC and BIC. Data extracted from completed surveys (excluding speeders). Models 1 through 4 were derived using the mixed logit methodology specified in equation (1) (preference space), and Model 5 was obtained using the mixed logit methodology as outlined in equation (4) ([WTP] space). In Model 1, the price coefficient is assumed to be normally distributed. Model 2 differs by fixing the price coefficient. Model 3 builds on Model 1 by introducing correlated random parameters, Model 4 extends Model 2 by incorporating correlated random parameters. In Model 5, the price coefficient is lognormally distributed.[+] */**/*** indicate the significance of the coefficients of the selected explanatory variables (plant health, human health, laboratory, computer, payment, and status quo) at the 10%/5%/1% level, respectively. To avoid perfect multicollinearity, only two out of the three values for the attributes related to the research focus (plant health and human health) and the research environment (laboratory and computer) are displayed in the first column. The monetary attribute (payment) is treated as a continuous variable.

Across Models 1 through 5, the attributes related to the research focus (plant health and human health), the monetary attribute (payment), and the status quo option are statistically significant at the 1% or 5% levels. The results provide evidence that participants place significantly higher valuations - approximately twice as much - on use values (human health) compared to non-use values (plant health), supporting Hypothesis 1. However, the coefficients for the variables related to the research environment (laboratory and computer) are not statistically significant, indicating no clear preference among participants for computer simulations over laboratory and field experiments from an ethical standpoint, as proposed in Hypothesis 2. Additionally, there is a consistent negative correlation between the payment amount and the WTP across all models, confirming Hypothesis 3. The data also reveal a strong negative preference against maintaining the status quo.

The WTP estimates are consistent across all models (see Table 7). These estimates are derived by dividing the coefficients of the non-monetary attributes by the payment coefficient (in Models 1 to 4), or they are directly represented as coefficients in the WTP space (Model 5). Table 7 presents WTP estimates only for those variables with statistically significant coefficients in Table 6, specifically for plant health and human health. The WTP estimates for human health range from 70 to 96 euros per year, while the estimates for plant health range from 32 to 41 euros per year. These expressed preferences are not uniform across the sample, as indicated by the significant standard deviations in all models in Table 6 (Chi2 test). Although Models 3 and 4 show some correlation between certain attribute coefficients, such as between Laboratory and Computer, Models 1, 2, and 5 are preferred based on the results of the AIC and BIC criteria, as well as the Chi2 tests.

Table 7. Annual WTP for Funding Research on Electromagnetic Field Effects on Green Roof Plants (€)

	Preference space				WTP space
	Model 1	Model 2	Model 3	Model 4	Model 5
Plant health	33,69	34,77	32,98	34,24	41,06
Human health	72,22	77,24	72,02	70,57	96,29

Note: Data extracted from completed surveys (excluding speeders). Models 1 through 4 were derived using the mixed logit methodology specified in equation (1) (preference space), and Model 5 was obtained using the mixed logit methodology as outlined in equation (4) ([WTP] space). In Model 1, the price coefficient is assumed to be normally distributed. Model 2 differs by fixing the price coefficient. Model 3 builds on Model 1 by introducing correlated random parameters, Model 4 extends Model 2 by incorporating correlated random parameters. In Model 5, the price coefficient is lognormally distributed. Estimates were derived with the delta method (Hole, 2007b).

Additional robustness tests are provided in Appendix A. In Table A.4, building on the data characterization analysis (Table 5), several robustness factors are controlled for, including low sensitivity to attributes, the presence of protesters, fairness concerns, non-plausibility, non-consequentiality, and distrust in institutions. These factors are combined with the status quo variable to assess their impact on this option. As previously discussed, these factors have the potential to bias WTP estimates. Model 6 in Table A.4 assumes the price coefficient to be normally distributed and serves as a comparison to Model 1 in Table 6. Among the factors combined with the status quo option, only non-plausibility is statistically significant, with a positive coefficient at the 1% level. This indicates that respondents who found the scenario non-plausible were more likely to choose the outside option. Preferences appear to be homogeneous across the sample, as the standard deviations associated with these robustness factors are not statistically significant in Table 6 (Chi2 test). The WTP estimates remain consistent with those in Models 1 to 5, with 74€ for human health and 34€ for plant health (Table A.6).

In Table A.4, we address the potential influence of age, given the overrepresentation of young respondents. Model 7 in Table A.5 also considers the price coefficient as normally distributed and is compared to Model 1 in Table 6. The results indicate no significant differences between Model 7 in Table A.5 and Model 1 in Table 6. The WTP estimates remain consistent, with 85€ for human health and 42€ for plant health (Table A.6).

The WTP values should not be viewed as precise financial estimates but rather as an indication of the relative importance participants place on human health versus plant health. These figures reflect a clear tendency for the public to prioritize human health over environmental factors, suggesting a greater willingness to allocate funds toward research addressing health-related issues. However, given the participants' unfamiliarity with green roofs and the self-reported nature of the preferences, these values must be interpreted in the context of generalized attitudes toward sustainability and health, rather than as exact financial commitments. Thus, these WTP values provide valuable insights into the public's broader preferences regarding health versus environmental sustainability, while also acknowledging the uncertainty inherent in stated preferences on complex, unfamiliar topics.

4.2 Analysis of Perceptions

Table 8 presents the results derived from applying the OLS approach to equation (5), which examines the determinants of risk perception related to the effects of RF-EMF. The table provides the estimated parameter values for the explanatory variables listed in the first column, the number of observations (#Obs.) used in each regression, and the F-statistic (F), which tests the joint significance of the explanatory variables.

The table specifically focuses on the risk perceptions associated with different organisms exposed to EMFs on a rooftop: a tree (columns 2 and 3), a person (columns 4 and 5), and a tree shielding a person (columns 6 and 7). The key explanatory variables used to capture the determinants of risk perception include affective, moral, and cognitive perceptions (columns 2, 4, and 6). Additionally, a variant of the model is presented where moral perceptions are considered only for participants aged 18 to 24 years (columns 3, 5, and 7).[5]

[5] The age variable "young" is a dummy variable that takes the value 1 is the respondent has between 18 and 24 years, and 0 otherwise.

Table 8. OLS Regression on the Determinants of Risk Perception

Dependent variable	**Risk perception**					
Explanatory variables	Tree exposure		Person exposure		Tree exposure (shielding a person)	
Affective perception	0,05	0,07	0,18	0,16	0,17**	0,18**
Moral perception	0,13*		-0,06		0,06	
Moral perception*Young		0,11		-0,02		-0,02
Cognitive perception	0,55**	0,57***	0,50***	0,49***	0,61***	0,65***
Female	-0,01	-0.07	-0,35	-0.33	-0,05	0,01
Education	0.06	0.22	0,18	0,13	0,06	0,01
Urban	-0,09	-0,09	-0,41	-0,41	-0,19	-0,24
Familiar	-0,12	-0,01	-0,56*	-0,56	0,09	0,11
Constant	0,92**	0,82*	1,92	1,96	0,70	0,93**
#Obs.	131	130	126	125	125	124
F	10,88***	10,64**	13,29***	13,25***	23,90***	23,69***

Note: The Ordinary Least Squares regression focuses on risk perceptions associated with different organisms exposed to EMFs on a rooftop: a tree (columns 2 and 3), a person (columns 4 and 5), and a tree shielding a person (columns 6 and 7). The key explanatory variables used to capture the determinants of risk perception include affective, moral, and cognitive perceptions (columns 2, 4, and 6). Additionally, a variant of the model is presented where moral perceptions are considered only for participants aged 18 to 24 years (columns 3, 5, and 7). A set of control variables was selected based on goodness-of-fit tests: “female,” “education,” “urban,” and “familiar.” Data extracted from completed surveys (excluding speeders). + */**/*** indicate the significance of the explanatory variables at the 10%/5%/1% level, respectively. T-statistics based on White heteroscedasticity consistent standard errors.

A set of control variables was selected based on goodness-of-fit tests: “female,” “education,” “urban,” and “familiar.” The “education” variable indicates whether the respondent has completed a baccalaureate, a professional certificate, a short higher education diploma, or a long higher education diploma. Variables related to income and socio-professional category were excluded due to their correlation with education. The “urban” variable refers to respondents living in a large city or its outskirts. Among the three variables related to respondents’ familiarity with green roofs, we retained the one with the highest statistical significance - whether the respondent had visited a green roof. Respondents identified as "speeders" were excluded from Table 8. Preliminary tests indicated that correlations were stronger between risk and cognitive perceptions than between risk perceptions and affective or moral perceptions (see Table A.9). Appendix A provides detailed descriptions of the variables included in the model, along with their descriptive statistics and the main correlations between perception variables (Tables A.7 to A.9).

In line with the findings of Freudenstein et al. (2015) on the role of cognitive perceptions in human exposure frameworks, our analysis shows that these perceptions play a dominant role in explaining risk perceptions associated with exposed organisms, whether the organism is a human or a plant shielding a human (Hypothesis 4). In fact, cognitive perceptions are the primary factor influencing risk perceptions, regardless of the exposed organism. In Table 8, the coefficients for cognitive perception are statistically significant at the 1-5% levels across all regressions and exhibit large values (ranging from 0.49 to 0.65). Specifically, all other factors being equal, a one-point increase in cognitive perception corresponds to a 0.55-point increase in risk perception. These values are particularly pronounced when the exposed organism is a tree shielding a person (0.61-0.65), compared to when it is a tree alone (0.55-0.57) or a person alone (0.49-0.50).

Furthermore, we find partial support for Hypothesis 5, as affective reactions are significant only when the exposed organism is a tree shielding a person, and not when it is a tree or a person alone. The coefficients for affective perception are statistically significant at the 5% level only when the organism exposed is a tree shielding a person (columns 6-7 in Table 8). In these cases, the coefficients range between 0.17 and 0.18, which are smaller than those associated with cognitive perception. Additionally, Hypothesis 6 is partially supported, as moral perceptions play a less significant role compared to cognitive and affective perceptions. The coefficients for moral perception are statistically significant at the 10% level only when the exposed organism is a tree, with a value of 0.13 (column 2 in Table 8). These coefficients lose significance when considering only respondents under 24 years old, who make up 57% of the sample (column 3 in Table 8). There is also some evidence that greater familiarity with green roofs is negatively correlated with risk perception, with a notably large coefficient (-0.56) when the exposed organism is a person alone (column 4 in Table 8).

A sensitivity analysis revealed that cognitive perception is the sole determinant of risk perception among participants under 34 years old (67% of the sample) (Table A.10). The coefficients for cognitive perception among younger participants are higher when the exposed organism is a tree shielding a person (0.61) compared to when it is a person alone (0.46). Affective and moral perceptions do not play a significant role in the analysis of younger participants. Additionally, living in a large city or its outskirts is significantly and negatively correlated with risk perception, with a large coefficient (-1.0) when the exposed organism is a person alone (column 3 in Table A.10).

When examining the typology of moral concerns related to the exposure of organisms to RF-EMF (questions 27-29), it is evident that respondents are primarily concerned with harm to the organism, regardless of the type of organism involved (Table 9). Specifically, for exposed trees, where significant statistical estimates were obtained in Table 8, respondents are most concerned with harm to the organism (24%) and harm to humans, who depend on nature (19%). To a lesser extent, respondents expressed concerns about the unfair exposure of the organism (16%) and the lack of consent by the organism (12%). Notably, about 20% of respondents reported having no moral concerns regarding exposed trees. Moral concerns are systematically higher for a tree shielding a person than for a tree alone and higher for a person than for a tree shielding a person. Concerns related to a lack of integrity (a lack of coherence between principles and values) are most pronounced for a tree shielding a person (16%), with these concerns combining those related to a tree (8%) and a person (11%).

Table 9. Distribution of Moral Perceptions Among Respondents (%)

Respondent	Tree	Person	Tree shielding a person
What are your moral concerns primarily associated with the picture, if any?			
I have no moral concerns	19,54	11,40	18,25
Harm to the organism	24,13	36,03	28,57
Harm to humans because humans depend on nature	19,54	-	-
Absence of consent by the organism	12,26	19,12	15,08
Unfair exposure of the organism	16,47	20,22	19,05
Lack of integrity (no coherence with principles and values)	7,66	11,40	15,87
Other: please specify	0,38	1,84	3,17

Note: This table reports the typology of moral concerns related to the exposure of organisms to RF-EMF (questions 27-29 in the survey). Data extracted from completed surveys. Multiple answers could be selected by respondents.

5 Discussion

This study offers important insights into how the public views the impact of mobile radiation on green roofs, but there are some limitations to consider that could affect how we interpret the results. One such limitation is the composition of the sample, which, while reflective of an urban French population, has a higher proportion of younger individuals, especially students aged 18 to 24. This demographic imbalance is important to note, as it may affect how the results are generalized. Younger respondents, particularly students, may have different views on technology and environmental issues compared to older groups. Additionally, the study depended on self-reported data, which can be influenced by biases like social desirability or response bias, potentially compromising the accuracy of the reported WTP and perceptions. Another limitation is the geographical focus, which was primarily on the Paris Region (Île de France). While Paris is highly urbanized and at the forefront of technological advancements, particularly 5G, the results may not be applicable to other regions with different levels of urbanization or environmental conditions. A more geographically diverse sample could offer insights into how public perceptions differ across regions, particularly in less urbanized areas or those with less exposure to emerging technologies like 5G.

While we acknowledge that the sample over-represents university students and is based in the Paris region, this focus was intentional for several key reasons. Paris, as a major urban center at the forefront of technological advancements, particularly 5G, provides a highly relevant context for this study. Moreover, university students are a particularly engaged demographic when it comes to new technology and environmental issues (Barrios-Ulloa et al., 2021). They are often early adopters of new technologies (Shah et al., 2023) and are highly involved in discussions around sustainability, which makes their perspectives pertinent for informing future policy frameworks related to green technologies. Shahzad et al. (2023) demonstrate that university students, being early adopters of new technologies, are highly attuned to sustainability concerns, making them an ideal group for exploring attitudes towards mobile radiation and its environmental impacts. Their awareness of environmental issues and tech-savviness positions

(Mustafa et al., 2022) them as an interesting demographic for understanding the relationship between emerging technologies and sustainability. This sample offers valuable insights, and while the generalizability may be limited, it provides a strong foundation for future research that can be expanded to more diverse populations and regions. However, expanding the sample to include a more diverse demographic and geographical contexts could provide a more comprehensive understanding of public perceptions. Furthermore, since the study used a survey-based approach, the preferences and perceptions gathered are based on hypothetical situations rather than actual decision-making scenarios, which might result in discrepancies between what people say they prefer and their real behaviors.

Despite these limitations, the study offers strong evidence that people are willing to financially support research on the effects of mobile radiation exposure on green roofs. The findings show a clear preference—about twice as much—for funding research focused on human health compared to plant health. Specifically, the WTP for human health is estimated to be between 70 and 96 euros per year for each mobile user, while the WTP for plant health is between 32 and 41 euros. While these figures reflect preferences, expanding the sample to include a broader demographic and geographic range could refine these estimates and provide a more nuanced understanding of how different groups prioritize human health and plant health. Although the WTP for plant health is lower, these amounts are still significant and should be factored into policy analyses. The results indicate that the public values both human and plant health, suggesting that both aspects need to be considered when developing research on the effects of mobile radiation on green roofs. While green roofs may provide some protection for humans against mobile radiation, it is important to also consider the potential effects on plant health when implementing these solutions. This finding suggests that current funding for research on mobile radiation effects should be more balanced, particularly since the existing funding for non-human organisms is relatively limited (Recuero Virto et al., 2024).

5.1 Theoretical Contributions

Our study offers several important contributions that challenge and refine current understandings, particularly regarding public perceptions and valuations related to green roofs and RF-EMF exposure.

First, our research highlights the prioritization of human health over plant health in public valuations, which has significant implications for the theoretical frameworks guiding sustainability research in IS. This finding aligns with existing literature emphasizing the importance of human well-being in sustainability initiatives, as noted by Melville (2010) and Kotlarsky et al. (2023). However, our results also indicate that while human health is a primary concern, the public's willingness to support environmental sustainability, especially when it involves complex and less tangible benefits like plant health, should not be underestimated. This nuanced dimension contributes to the DS framework by showing that public support for sustainability (Corbett et al., 2020) is not uniform but varies based on the perceived directness of benefits. These findings resonate with the work of Watson et al. (2021), who argue that sustainability initiatives need to bridge gaps between environmental and social priorities to achieve broader acceptance. This insight becomes even more important when considering the sample's demographic—primarily young, tech-savvy university students, whose perspectives on technology's role in sustainability could differ from older generations or those from less urbanized regions. Thus, expanding the sample to a more demographically and geographically diverse group would likely yield further insights into how sustainability is perceived across different segments of the population. The prioritization of human health mirrors insights from Corbett and Dennehy (2023), who emphasize that public engagement in sustainability efforts hinges on addressing immediate, personal benefits alongside long-term ecological goals. Moreover, this challenges the traditional focus of Green IS, which has often emphasized overarching environmental goals (Hedman & Henningsson, 2016), by highlighting the relative importance of human-centric outcomes. Building on the hyper-modernity perspective discussed by El Idrissi and Corbett (2016), our findings suggest that public valuations reflect a combination of immediate utility and ethical considerations, particularly in urban contexts where sustainability is closely tied to livability. This underscores the necessity for IS research to move beyond generalized sustainability objectives and consider specific public preferences and trade-offs, as suggested by Pernici et al. (2012). Such considerations are vital for designing information systems that effectively balance human and environmental health, thereby advancing the dual goals of ecological preservation and social well-being.

Then, our findings contribute to the ethical discourse in IS by revealing that the public does not exhibit a strong preference for digital methods, such as computer simulations, over more traditional research methods like laboratory and field experiments. This challenges the assumption within IS that digital tools are universally perceived as more ethically favorable (Butler, 2011). While computer simulations offer non-invasive and ethically appealing alternatives, our results suggest that public preferences are influenced by the perceived efficacy and realism of research methods, as noted by El Idrissi and Corbett (2016), who emphasize the interplay between practical utility and ethical abstraction in modern IS research. This insight aligns with the broader discourse on ethical design and implementation within Green IS, as discussed by Pernici et al. (2012), which highlights the importance of balancing ethical considerations with operational effectiveness. Similarly, the findings underscore the complexity of ethical decision-making in DS initiatives, echoing Shin and Dedrick’s (2024) observation that public perceptions of sustainability technologies often involve trade-offs between ethical and practical considerations. For example, while digital simulations minimize harm to non-human organisms, their perceived abstraction may raise questions about the validity of results compared to hands-on methodologies like field experiments (Watson et al., 2021). Furthermore, this nuanced understanding of ethical perceptions suggests a need for a more balanced approach in IS research and practice. As Corbett et al. (2023) note, ethical design in IS must not only align with societal expectations but also ensure the legitimacy and reliability of outcomes. This dual focus is critical for advancing DS initiatives that resonate with public values while maintaining scientific rigor. By integrating public preferences into the design of IS-driven sustainability efforts, researchers can address the ethical and practical dimensions simultaneously, thereby fostering greater public trust and engagement in sustainability initiatives.

Additionally, the strong negative correlation between payment and WTP in our study adds a new economic dimension to the DS literature. While cost-benefit analyses are a well-established tool for assessing the viability of sustainability initiatives (Dao et al., 2011), our findings extend this perspective by demonstrating that public support is significantly influenced by the financial burden associated with these initiatives. This underscores the importance of designing cost-effective sustainability measures that align with public financial constraints, a consideration often underemphasized in the literature on Green IS and DS (Ryoo & Koo, 2013). This economic dimension is also evident in Shin and Dedrick’s (2024) exploration of the environmental Kuznets curve, which illustrates how economic development stages affect environmental behaviors and investments. Their findings suggest that public support for sustainability initiatives varies across economic contexts, with wealthier populations exhibiting greater flexibility in their willingness to absorb financial burdens for environmental benefits. This aligns with our observation that economic feasibility is a decisive factor in public valuations, emphasizing the need for IS frameworks to address these variations in economic capacity when designing sustainability initiatives. Moreover, the integration of economic realities into IS frameworks is critical for ensuring long-term viability and widespread adoption of sustainability efforts. Pernici et al. (2012) highlight the role of Green IS in promoting energy efficiency and resource optimization, which can reduce operational costs and make sustainability initiatives more financially viable. This perspective reinforces the need for IS researchers to adopt a systems-level approach that incorporates cost considerations alongside environmental and ethical factors. For instance, the design of IS solutions could leverage scalable technologies, such as energy-efficient data centers or shared resource systems, to minimize economic barriers to adoption while maintaining environmental integrity. The findings also resonate with Corbett et al.'s (2023) discussion on the intersection of economic and environmental goals in IS research. They argue that achieving sustainability often requires reconciling conflicting priorities, such as short-term economic constraints and long-term environmental objectives. Our study contributes to this discourse by emphasizing the critical role of public financial constraints in shaping support for DS initiatives. Addressing these constraints through innovative IS designs, such as cost-sharing mechanisms or incentives for participation, could enhance public engagement and ensure the equitable distribution of sustainability benefits. This economic dimension aligns with broader trends in IS research that advocate for actionable outcomes and measurable impacts, as articulated by Watson et al. (2021). By incorporating economic feasibility into DS models, IS researchers can create sustainability solutions that are not only ethically and environmentally sound but also economically sustainable, fostering greater public acceptance and long-term success.

Our study also advances the understanding of risk perceptions in IS by showing that cognitive perceptions play a dominant role in shaping public attitudes toward the risks associated with RF-EMF exposure. This finding aligns with the work of Freudenstein et al. (2015) but extends it by applying it to the context of DS. The emphasis on cognitive perceptions suggests that public support for DS initiatives can be enhanced through better education and information dissemination. This is consistent with Corbett et al. (2023), who highlight the role of digital innovation in fostering social and environmental engagement through targeted communication strategies. Educating the public about the tangible benefits and risks of digital technologies, such as RF-EMF exposure, can mitigate misinformation and build trust, a critical insight for

IS researchers designing sustainability initiatives. Furthermore, our research highlights the significant, though secondary, roles of affective and moral perceptions, particularly in contexts where the public has a direct emotional or ethical stake. Brosch and Steg (2021) emphasize the power of affective responses in driving public engagement with environmental issues, a finding echoed in the interdisciplinary perspective advocated by Pernici et al. (2012). By integrating these emotional and ethical dimensions into IS frameworks, researchers can develop more inclusive and effective strategies for public engagement. For instance, incorporating affective appeals into digital platforms or applications could enhance public receptivity to sustainability messages while aligning with ethical principles. Additionally, our findings underscore the importance of a holistic approach in IS that considers the full spectrum of cognitive, affective, and moral factors in public engagement with sustainability issues. This aligns with the socio-technical-ecological systems (STES) perspective introduced by Ahlborg et al. (2019), which calls for a broader view that integrates technological, social, and environmental dimensions. By examining the interplay between cognitive, affective, and moral perceptions in the context of green roofs and RF-EMF exposure, our study provides a more comprehensive understanding of how IS can be leveraged to address complex sustainability challenges. This aligns with Watson et al. (2021), who argue for interdisciplinary approaches that bridge environmental science with digital technology to address wicked problems in sustainability. The findings suggest that successful DS initiatives will require IS researchers to collaborate closely with environmental scientists, policymakers, and other stakeholders to ensure technological solutions are aligned with public values and environmental goals. Shin and Dedrick (2024) highlight the importance of cross-disciplinary partnerships in addressing environmental challenges, emphasizing that IS researchers cannot operate in isolation when designing effective sustainability interventions. This integration of expertise is crucial for ensuring that DS strategies are both technologically advanced and socially and environmentally responsible. By embracing interdisciplinary collaboration, IS can drive the development of holistic solutions that resonate with diverse stakeholder groups while advancing global sustainability objectives.

Our research enhances the understanding of how environmental, social, and economic sustainability outcomes are interconnected within the IS field, especially regarding public support for green roofs in the context of RF-EMF exposure. While earlier studies have often examined these outcomes separately, our findings offer a more holistic view by showing how public perceptions and valuations influence multiple sustainability dimensions at once. For instance, Shin and Dedrick (2024) emphasize that sustainability outcomes are often nonlinear, requiring a careful balance between immediate environmental impacts and long-term economic viability, which our study reflects by highlighting the interdependence of public perceptions on these factors. For example, our study reveals that prioritizing human health—an element of social sustainability—over plant health reflects not just individual preferences but also highlights the wider economic and ethical factors involved in backing sustainable technologies. This perspective aligns with existing literature that underscores the interdependence of sustainability outcomes, as demonstrated by Ryoo and Koo (2013) and Kurkalova and Carter (2017), who illustrated how strong environmental performance can lead to economic advantages. Additionally, Pernici et al. (2012) argue that sustainable IS design must incorporate social and ethical dimensions to ensure broader adoption, an approach echoed in our findings that public support for green roofs is shaped by the interplay of cognitive, affective, and moral factors. However, our research takes this discussion further by demonstrating that public support for such initiatives relies on a balanced consideration of all three sustainability outcomes. This balanced consideration would likely change if the study were expanded to different demographics and regions, as responses might vary according to socio-economic and environmental contexts. Watson et al. (2021) highlight the need for integrative frameworks in IS research that address the complex trade-offs between environmental, social, and economic dimensions, a call that our findings directly respond to by offering evidence of how public valuations shift based on their perceptions of these trade-offs. Specifically, the cognitive, affective, and moral perceptions we explored indicate that the public's risk assessments and support for sustainability initiatives like green roofs are closely tied to their broader understanding of how these initiatives promote environmental health, social equity, and economic stability. Furthermore, this integrative perspective aligns with the STES framework proposed by Ahlborg et al. (2019), which calls for IS research to embrace interdisciplinary approaches to sustainability. By examining public attitudes towards RF-EMF exposure and green roofs, our study contributes to this framework by providing empirical evidence on how different sustainability dimensions intersect in public discourse. As Corbett et al. (2023) emphasize, such interdisciplinary insights are important for designing DS initiatives that are both effective and equitable, ensuring that technological advancements align with public values while addressing environmental and social challenges. Ultimately, the findings reinforce the necessity for IS researchers to adopt a systems-level approach to sustainability that integrates environmental, social, and economic considerations. Expanding research to a more diverse sample would allow for a broader understanding of the nuances in public perceptions across different regions, particularly in rural or economically disadvantaged areas. This holistic perspective enables the development of more inclusive and resilient DS strategies, fostering public trust and engagement while addressing the complex challenges of sustainable urban development. Considering these findings, future research should explore how public perceptions might differ across various populations, using a more diversified sample to refine the models for sustainable urban planning and technology integration.

5.2 Practical/Policy Contributions

Building on our findings, our research offers several practical and policy contributions pivotal for advancing DS initiatives, particularly those intersecting urban planning, public health, and environmental management. One significant contribution is the insight that policymakers must craft nuanced and targeted communication strategies that address the complex interplay between public perceptions of risk and their support for sustainability initiatives. Given the dominant role of cognitive perceptions—rooted in factual knowledge and rational analysis—in shaping public risk assessments, it is important for policymakers to prioritize transparent and accessible dissemination of information. Policymakers should leverage digital platforms and innovative IS tools to educate the public about the risks and benefits associated with technologies like green roofs and RF-EMF exposure. These digital tools should be adaptable to different audiences, incorporating varying levels of technological and environmental awareness. These platforms can facilitate two-way communication, enabling policymakers to address concerns in real time while enhancing the legitimacy and acceptance of sustainability policies. Interactive elements, such as webinars, virtual town halls, and crowdsourcing platforms, could serve to involve the public directly in decision-making processes, building trust and long-term support.

Our research also underscores the importance of balancing ethical considerations with public preferences in the development and deployment of research methodologies. Despite the ethical advantages of digital simulations, the public's lack of strong preference for these methods over traditional laboratory or field experiments indicates that policymakers and researchers must tread carefully. This finding suggests that sustainability policies should incorporate participatory approaches, actively soliciting public input to ensure alignment with societal expectations and ethical standards. Co-creation workshops or citizen panels could be used to gather feedback during the design phase of DS initiatives, ensuring policies are both ethically sound and publicly acceptable. Such practices would not only enhance the legitimacy of these initiatives but also foster a sense of shared ownership, increasing societal buy-in and long-term success. Another critical contribution of our research lies in its insights into public willingness to pay for sustainability initiatives, particularly the differentiation between human health and environmental health priorities. To align funding structures with public preferences, policymakers should consider adopting tiered or flexible funding models. These models could allow individuals to contribute incrementally based on their personal valuations, making sustainability projects more inclusive and financially viable. For instance, policies could introduce opt-in schemes where citizens can allocate contributions to specific aspects of green infrastructure projects, such as health-focused or biodiversity-focused initiatives. This approach would improve participation rates and reflect public priorities, ensuring equitable and broad-based support.

Our findings also highlight the need for economic incentives to drive greater public engagement in sustainability initiatives. Policymakers could explore mechanisms such as tax credits for individual contributions to green infrastructure, subsidies for households adopting eco-friendly technologies, or community grant programs for neighborhoods supporting green roofs and RF-EMF research. Additionally, introducing dynamic pricing models that lower the financial barrier for lower-income groups could foster inclusivity and equity in participation. By implementing these practical solutions, governments could ensure sustainability efforts are both widely supported and economically sustainable over time. Public perceptions are important in designing equitable funding mechanisms that garner broad support. The study's findings suggest that human health is prioritized over plant health, but both are viewed as important, highlighting the need for funding frameworks that balance these concerns. Transparent communication about how funds are allocated, and clear connections between funding outcomes and public benefits, can improve public engagement. Policymakers could consider tiered funding mechanisms where research addressing public health risks receives more immediate support, while sustainability-oriented research receives long-term funding. These approaches can be designed to align with public preferences, ensuring that both human and environmental concerns are equitably addressed. Additionally, policymakers should focus on building institutional trust by ensuring that funding decisions are made with transparency and that public accountability is emphasized in research outcomes.

Effective governance emerges as another cornerstone of successful DS initiatives. Governance frameworks must integrate environmental, social, and economic dimensions of sustainability while remaining adaptable to public concerns and perceptions. Policymakers should establish multi-stakeholder governance bodies that include representatives from public health, urban planning, environmental science, and the general public. These governance bodies could oversee the implementation and monitoring of green technologies, ensuring they meet sustainability objectives while addressing evolving public concerns. Furthermore, these entities could act as mediators, facilitating dialogue between various stakeholders to resolve conflicts and enhance policy adaptability in response to changing environmental or technological challenges. To further strengthen governance, policymakers could introduce performance metrics that assess the effectiveness of DS initiatives in real time. Key performance indicators, such as reductions in urban heat islands, improvements in air quality, or increased biodiversity levels, could provide tangible benchmarks for evaluating the impact of green roofs and other sustainability measures. Publicly accessible dashboards displaying these metrics would enhance transparency, fostering trust in governance processes and encouraging ongoing public participation. Additionally, given the significant differences in WTP for human versus plant health, policymakers should consider prioritizing human health in the short term due to the higher WTP observed. However, it is important to recognize the ongoing public concern for plant health and environmental sustainability. A balanced approach that addresses both immediate human health risks and long-term environmental goals could be beneficial. Policymakers may also explore tiered funding mechanisms, where human health-related initiatives receive more immediate funding, while sustainability-oriented projects related to plant health receive sustained, albeit more gradual, funding.

Lastly, our findings call attention to the importance of fostering community-level engagement to ensure the localized success of DS initiatives. Policymakers should prioritize programs that empower communities to take ownership of green infrastructure projects, such as grant funding for local initiatives or capacity-building workshops. These programs could be tailored to address specific community needs, such as mitigating RF-EMF exposure in residential areas or enhancing urban green spaces to improve health and well-being. By building localized support networks and empowering communities, policymakers can ensure that DS initiatives are not only technically successful but also socially embedded, fostering long-term resilience and adaptability.

6 Conclusion

This study has explored the public's willingness to fund research on the effects of mobile radiation on green roofs, revealing a clear preference for prioritizing human health over plant health, yet also recognizing the significance of both. The findings underscore the importance of integrating both human and environmental considerations into future urban sustainability initiatives, particularly in the context of rapidly advancing digital technologies. The lack of strong preference for specific research environments, such as computer simulations versus traditional laboratory settings, suggests that ethical considerations may not be as influential in public decision-making as previously assumed. On the other hand, while the study did not reveal a significant preference for computer simulations, this suggests the need for qualitative follow-up research. Focus groups or interviews could help uncover underlying perceptions regarding the credibility, usefulness, and comprehensibility of computer simulations. Such research could provide valuable insights into public hesitations or lack of preference for these tools, ultimately guiding the design of simulation-based initiatives and educational campaigns aimed at improving public engagement with these technologies. Moreover, the survey content explicitly stated that computer models are always different from real organisms (see Appendix A). Simulations are indeed limited in terms of extrapolations to field exposure under the presence of multiple stressors, including exposure to RF-EMF. Conditional on this aspect, respondents may have a lower preference for computer simulations than was anticipated in H2. Overall, the dominance of cognitive perceptions in shaping risk assessments highlights the necessity for evidence-based communication strategies that effectively convey the risks and benefits associated with digital technologies like 5G. In addition, the broader context of urban policy trends must be considered. As many countries shift away from land sprawling—a historical pattern of unrestricted growth involving expansive land use—toward vertical urbanization, there are significant implications for sustainability. This transition, driven by global climate agendas, is aimed at reducing energy consumption and lowering the costs of managing essential infrastructures such as energy networks, water, telecommunications, and waste management. For regions like the United States and North Africa, this represents a relatively recent policy shift with far-reaching impacts.

In terms of practical implications, policymakers should consider the nuanced preferences revealed by this study when allocating funds and designing public engagement strategies. By addressing both cognitive and emotional dimensions of risk perception, and by ensuring that public concerns about fairness and environmental impact are adequately addressed, it is possible to foster broader support for sustainability initiatives. Moreover, this study's findings align with these emerging urbanization policies, highlighting the need to harmonize technological and ecological goals as part of this vertical urbanization shift. Looking forward, future research should aim to address the limitations identified in this study, particularly by expanding the demographic diversity of survey respondents and exploring the applicability of these findings in different geographical contexts. Further investigation into the long-term effects of mobile radiation on plant health and the potential cumulative impacts on urban ecosystems would also be valuable. Additionally, research could look deeper into understanding how different demographic groups perceive the ethical implications of digital technologies, especially as these technologies continue to evolve. Another promising avenue for future research lies in exploring the integration of advanced IS tools, such as AI and big data analytics, to monitor and mitigate the impacts of mobile radiation on green roofs. By leveraging these technologies, it may be possible to develop more precise and adaptive strategies for managing urban environments in ways that harmonize technological progress with ecological sustainability. Furthermore, future studies could explore additional attributes, such as biodiversity and energy savings, as well as payment vehicle options, such as voluntary contributions, to further understand the broader public preferences and inform urban sustainability initiatives.

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Appendix A

Table A.1. French Statistics: Gender, Age, Location, and Socio-Professional Category (%)

Respondent	Sample (%)
Gender	
Females	52
Males	48
Age	
18-24	11
25-34	16
35-44	18
45-54	18
55-64	15
65+	22
Region (UDA5)	
Ile de France	19
Northwest	23
Northeast	23
Southwest	11
Southeast	24
Socio professional category (detailed)	
Business Manager / Independent (Farmer + Artisan, Merchants + Business Manager)	5
Managerial staff	10
Intermediate professions	15
Employees	17
Workers	13
Retired	28
Student	4
Other inactive	8
Socio-professional category (summary)	
Socio-professional category (plus)	31
Socio-professional category (minus)	32
Inactive	37

Note: Data provided by Nydata according to French national statistics.

Table A.2. Complementary Descriptive Statistics for the Sample (%)

Respondent	Sample (%)
Income	
0 to 10,000 euros	32,54
10,001 to 20,000 euros	9,47
20,001 to 30,000 euros	10,06
30,001 to 40,000 euros	12,43
over 40,000 euros	18,93
no answer	16,57
Highest completed level of education	
no primary education diploma or certificate	0,59
college certificate	0,59
CAP, BEP or equivalent	2,37
baccalaureate, professional certificate or equivalent	53,25
short higher education diploma (bac + 2 level)	15,38
long higher education diploma (higher than bac + 2)	26,63
no answer	1,18
Location	
a big city	30,18
the suburbs or outskirts of a big city	48,52
a town or a small city	12,43
a country village	7,10
a farm or home in the countryside	0,59
other/ no answer	1,18

Note: Data extracted from completed surveys.

Table A.3 Mixed Logit Analysis of Individual Preferences for Funding Research on Electromagnetic Field Effects on Green Roof Plants

	Preference space				WTP space
Explanatory variables	Model 1	Model 2	Model 3	Model 4	Model 5
COEFFICIENTS					
Plants health	0,365***	0,342***	0,412***	0,350***	41,06**
Human health	0,783***	0,759***	0,849***	0,766***	96,29**
Laboratory	-0,194	-0,172	-0,230	-0,223*	-11,91
Computer	-0,143	-0,129	-0,169	-0,181	-15,25
Payment	-0,010***	-0,009***	-0,012***	-0,010***	-4,98***
Status quo	-2,480***	-2,444***	-2,570***	-2,538***	-491,64***
STANDARD DEVIATION					
Plants health	-0,713***	0,682***	0,821***	0,734***	-64,96***
Human health	1,190***	1,132***	1,442***	1,289***	89,94**
Laboratory	0,020	0,028	0,610**	-0,336	14,21
Computer	-0,469**	-0,446*	0,238	-0,249**	-37,66
Payment	0,016**		0,015*		1,26***
Status quo	2,436***	2,431***	1,813***	2,002***	-443,62*
Plants health*Human health			0,274	0,229	
Plants health*Laboratory			-0,272	-0,312	
Plants health*Computer			-0,365	-0,306	
Plants health*Payment			-0,000		
Plants health*Status quo			0,099	-0,473	
Human health*Laboratory			0,125	0,103	
Human health*Computer			-0,434	-0,417*	
Human health*Payment			-0,002		
Human health*Status quo			-0,880*	-0,763**	
Laboratory*Computer			0,716**	-0,481	
Laboratory*Payment			-0,012		
Laboratory*Status quo			-0,001	0,437	
Computer*Payment			0,000		
Computer*Status quo			1,256*	-0,964	
Payment*Status quo			-0,630		
#Obs	2 970	2 970	2 970	2 970	2 970
#Individuals	165	165	165	165	165
#Draws	1000	1000	600	600	530
#Estimations	9	7	9	11	14
Chi2	81,51***	85,27***	18,06ǂ	13,71ǂ	36,05***
Log-like.	-878,43	-879,27	-869,40	-872,47	-874,52
AIC	1780,86	1780,54	1792,81	1786,95	1773,05
BIC	1852,82	1846,50	1954,71	1912,87	1845,01

Note: The table details the estimated values of the parameters associated with the explanatory variables listed in the first column, the standard deviations associated with these explanatory variables, correlated random parameters, the number of observations (#Obs.), the number of individuals (#Individuals), the number of draws (#Draws), the number of estimations (#Estimations), a chi-squared (Chi2) test for the joint significance of the coefficients for standard deviations, and several goodness-of-fit measures (Log-like., AIC, BIC). Data extracted from completed surveys (excluding speeders). [+] */**/*** indicate the significance of the coefficients of the explanatory variables at the 10%/5%/1% level, respectively. Models 1 through 4 were derived using the mixed logit methodology specified in equation (1) (preference space), Model 5 was obtained using the mixed logit methodology as outlined in equation (4) ([WTP] space). In Model 1, the price coefficient is assumed to be normally distributed. Model 2 differs by fixing the price coefficient. Model 3 builds on Model 1 by introducing correlated random parameters, Model 4 extends Model 2 by incorporating correlated random parameters. In Model 5, the price coefficient is lognormally distributed. ǂ: Chi2 test on whether Model 1 is nested in Model 3 (column 4) and Model 2 in 4 (column 5). [+] */**/*** indicate the significance of the coefficients of the selected explanatory variables (plants health, human health, laboratory, computer, payment, and status quo) at the 10%/5%/1% level, respectively. To avoid perfect multicollinearity, only two out of the three values for the attributes related to the research focus (plant health and human health) and the research environment (laboratory and computer) are displayed in the first column. The monetary attribute (payment) is treated as a continuous variable. The sign of the estimated standard deviations is irrelevant: interpret them as being positive.

Table A.4. Mixed Logit Regression on Individuals' Preference Concerning Funding the Research on the Effects of Electromagnetic Fields on Plants in Green Roofs: Robustness Test (I)

	Preference space
Explanatory variables	Model 6
COEFFICIENTS	
Plants health	0,381***
Human health	0,821***
Laboratory	-0,209
Computer	-0,153
Payment	-0,011***
Status quo	-2,306***
Status quo*Low sensitivity to attributes	-26,511
Status quo*Protesters	46,732
Status quo*Fairness concerns	-1,036
Status quo*Non-plausibility	2,142***
Status quo*Non-consequentiality	-0,496
Status quo*Contesting institutions	0,092
STANDARD DEVIATION	
Plants health	0,742***
Human health	1,267***
Laboratory	-0,028
Computer	-0,570***
Payment	0,018***
Status quo	1,183***
Status quo*Low sensitivity to attributes	0,274
Status quo*Protesters	0,143
Status quo*Fairness concerns	-0,316
Status quo*Non-plausibility	1,682
Status quo*Non-consequentiality	0,264
Status quo*Contesting institutions	0,753
#Obs	2 970
#Individuals	165
#Draws	1000
#Estimations	9
Chi2	69,87***
Log-like.	-845,53
AIC	1739,07
BIC	1882,98

Note: The table details the estimated values of the parameters associated with the explanatory variables listed in the first column, the standard deviations associated with these explanatory variables, correlated random parameters, the number of observations (#Obs.), the number of individuals (#Individuals), the number of draws (#Draws), the number of estimations (#Estimations), a chi-squared (Chi2) test for the joint significance of the coefficients for standard deviations, and several goodness-of-fit measures (Log-like., AIC, BIC). Data extracted from completed surveys (excluding speeders). + */**/*** indicate the significance of the coefficients of the explanatory variables at the 10%/5%/1% level, respectively. The sign of the estimated standard deviations is irrelevant: interpret them as being positive. See section 3.1. on respondents' characteristics for a definition of the robustness factors (low sensitivity to attributes, protesters, fairness concerns, non-plausibility, non-consequentiality, and contesting institutions). In Model 6, the price coefficient is normally distributed. Other models have similar results and are available upon request (e.g., price fixed).

Table A.5. Mixed Logit Regression on Individuals' Preference Concerning Funding the Research on the Effects of Electromagnetic Fields on Plants in Green Roofs: Robustness Test (II)

	Preference space
Explanatory variables	Model 7
COEFFICIENTS	
Plants health	0,348**
Human health	0,703***
Laboratory	-0,121
Computer	-0,167
Payment	-0,008**
Status quo	-1,953***
STANDARD DEVIATION	
Plants health	0,687***
Human health	0,934***
Laboratory	0,003
Computer	-0,383
Payment	0,005
Status quo	1,584***
#Obs	1 980
#Individuals	110
#Draws	1000
#Estimations	9
Chi2	47,98***
Log-like.	-606,33
AIC	1236,66
BIC	1303,75

Note: The table details the estimated values of the parameters associated with the explanatory variables listed in the first column, the standard deviations associated with these explanatory variables, correlated random parameters, the number of observations (#Obs.), the number of individuals (#Individuals), the number of draws (#Draws), the number of estimations (#Estimations), a chi-squared (Chi2) test for the joint significance of the coefficients for standard deviations, and several goodness-of-fit measures (Log-like., AIC, BIC). Data extracted from completed surveys (excluding speeders). + */**/*** indicate the significance of the coefficients of the explanatory variables at the 10%/5%/1% level, respectively. The sign of the estimated standard deviations is irrelevant: interpret them as being positive. The model includes only respondents between 18 and 34 years old. The price coefficient is normally distributed. Other models have similar results and are available upon request (e.g., price fixed).

Table A.6. WTP Per Year Concerning Funding the Research on the Effects of Electromagnetic Fields on Plants in Green Roofs (€)

	Preference space	
	Model 6	Model 7
Plants health	34,77	42,49
Human health	74,14	85,82

Note: In model 6, respondents' characteristics are accounted for regarding robustness factors (low sensitivity to attributes, protesters, fairness concerns, non-plausibility, non-consequentiality, and contesting institutions). The model 7 includes only respondents between 18 and 34 years old. In Models 6 and 7, the price coefficient is normally distributed. Data extracted from completed surveys (excluding speeders). Estimates were derived with the delta method (Hole, 2007b).

Table A.7. The Analysis of Perception: Variables Included in the Models

Designation	Content
Perception	
Affective perception (tree)	Discrete variable that takes values between 1 and 6 for the first image (tree). Higher values imply higher affective perception.
Affective perception (person)	Discrete variable that takes values between 1 and 6 for the second image (person). Higher values imply higher affective perception.
Affective perception (shielding tree)	Discrete variable that takes values between 1 and 6 for the third image (tree shielding a person). Higher values imply higher affective perception.
Moral perception (tree)	Discrete variable that takes values between 1 and 6 for the first image (tree). Higher values imply higher moral perception.
Moral perception (person)	Discrete variable that takes values between 1 and 6 for the second image (person). Higher values imply higher moral perception.
Moral perception (shielding tree)	Discrete variable that takes values between 1 and 6 for the third image (tree shielding a person). Higher values imply higher moral perception.
Cognitive perception (tree)	Discrete variable that takes values between 1 and 6 for the first image (tree). Higher values imply higher cognitive perception.
Cognitive perception (person)	Discrete variable that takes values between 1 and 6 for the second image (person). Higher values imply higher cognitive perception.
Cognitive perception (shielding tree)	Discrete variable that takes values between 1 and 6 for the third image (tree shielding a person). Higher values imply higher cognitive perception.
Risk perception (tree)	Discrete variable that takes values between 1 and 6 for the first image (tree). Higher values imply higher risk perception.
Risk perception (person)	Discrete variable that takes values between 1 and 6 for the second image (person). Higher values imply higher risk perception.
Risk perception (shielding tree)	Discrete variable that takes values between 1 and 6 for the third image (tree shielding a person). Higher values imply higher risk perception.
Controls	
Young	Dummy variable that takes the value 1 if the respondent is between 18 and 24 years old, and 0 otherwise.
Female	Dummy variable that takes the value 1 if the respondent is a female, and 0 otherwise.
Education	Discrete variable that takes values between 1 and 3 to reflect the highest education level completed by respondents. The value 1 designates baccalaureate, professional certificate, or equivalent, the value the value 2 designates short higher education diploma (bac +2 level), and 3 designates long higher education diploma (higher than bac +2)).
Urban	Dummy variable that takes the value 1 if the respondent lives in a big city or in the suburbs or outskirts of a bug city, and 0 otherwise.
Familiar	Dummy variable that takes the value 1 if the respondent has visited a green roof, and 0 otherwise.

Table A.8. The Analysis of Perceptions: Summary Statistics

Designation	Obs.	Median	Mean	Std dev.	Min.	Max.
Perceptions						
Affective perception (tree)	159	3	3,28	1,66	1	6
Affective perception (person)	159	4	4,06	1,63	1	6
Affective perception (shielding tree)	160	4	3,90	1,66	1	6
Moral perception (tree)	154	3	3,37	1,73	1	6
Moral perception (person)	155	4	3,90	1,72	1	6
Moral perception (shielding tree)	151	4	3,88	1,60	1	6
Cognitive perception (tree)	158	4	3,60	1,53	1	6
Cognitive perception (person)	153	5	4,21	1,69	1	6
Cognitive perception (shielding tree)	155	4	4,09	1,64	1	6
Risk perception (tree)	153	4	3,60	1,73	1	6
Risk perception (person)	151	5	4,35	1,57	1	6
Risk perception (shielding tree)	153	5	4,20	1,60	1	6
Controls						
Young	168	1	0,57	0,49	0	1
Female	169	0	0,46	0,50	0	1
Education	167	1	1,69	0,86	1	3
Urban	167	1	0,79	0,40	0	1
Familiar	169	0	0,10	0,30	0	1

Note: Data extracted from completed surveys.

Table A.9. The Analysis of Perceptions: Correlations (Perceptions)

		Affective perception			Moral perception			Cognitive perception			Risk perception		
		Tree	Person	Sh. Tree	Tree	Person	Sh. Tree	Tree	Person	Sh. Tree	Tree	Person	Sh. Tree
Affe. Percep.	Tree	1,00											
	Person	0,40	1,00										
	Sh. Tree	0,39	0,43	1,00									
Moral percep.	Tree	0,44	0,34	0,40	1,00								
	Person	0,34	0,61	0,22	0,43	1,00							
	Sh. Tree	0,34	0,43	0,44	0,70	0,60	1,00						
Cog. Percep.	Tree	0,29	0,28	0,18	0,35	0,16	0,25	1,00					
	Person	0,13	0,49	0,14	0,28	0,55	0,40	0,43	1,00				
	Sh. Tree	0,22	0,39	0,27	0,38	0,26	0,28	0,58	0,52	1,00			
Risk percep.	Tree	0,29	0,34	0,35	0,34	0,32	0,37	0,58	0,38	0,34	1,00		
	Person	0,20	0,44	0,15	0,12	0,44	0,24	0,37	0,65	0,37	0,43	1,00	
	Sh. Tree	0,33	0,51	0,37	0,32	0,33	0,28	0,49	0,42	0,59	0,55	0,60	1,00

Note: Data extracted from completed surveys. The full correlation matrix is available upon request.

Table A.10. OLS Regression on the Determinants of Risk Perception (Younger Respondents)

Dependent variable	Risk perception		
Explanatory variables	Tree exposure	Person exposure	Tree exposure (shielding a person)
Affective perception	0,03	0,16	0,10
Moral perception	0,04	-0,12	0,06
Cognitive perception	0,62***	0,46***	0,61***
Female	0,14	-0,48*	-0,09
Education	0,06	0,31*	0,06
Urban	0,01	-1,0***	-0,46
Familiar	-0,11	-0,46	-0,23
Constant	0,95	2,76	1,23*
Obs.	89	87	82
F	8,07***	8,06***	10,39***

Note: The Ordinary Least Squares (OLS) regression focuses on risk perceptions associated with different organisms exposed to EMFs on a rooftop: a tree (column 2), a person (column 3), and a tree shielding a person (column 4). The key explanatory variables used to capture the determinants of risk perception include affective, moral, and cognitive perceptions (columns 2, 4, and 6). The regression only considers participants aged 18 to 34 years. A set of control variables was selected based on goodness-of-fit tests: "female," "education," "urban," and "familiar." Data extracted from completed surveys (excluding speeders). + */**/*** indicate the significance at the 10%/5%/1% level, respectively. T-statistics based on White heteroscedasticity consistent standard errors. Only respondents under the age of 34 are included in the sample.

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