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Abstract This report introduces the KSI (Key Sustainability Indicator) Framework developed by the 6G4Society project, addressing the fundamental challenge of embedding social sustainability values into the development of 6G networks. The framework offers conceptual clarity, value definitions, and a practical process for translating stakeholder pain points, impacts, and key decisions into relevant indicators. The framework builds upon and further establishes practical guidance for Key Value Indicators (KVIs), which track long-term stakeholder outcomes and impacts, distinguishing them from traditional

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technical Key Performance Indicators (KPIs) and User Experience (UX) metrics. The Framework proposes a strategic transition from more immediate value snapshots (KVs) to Key Sustainability Indicators (KSIs) that assess systemic, long-term change through five core principles: holistic assessment, trade-off mapping, future orientation, stakeholder engagement, and boundary identification. Practical contributions include a structured process for stakeholder-driven value mapping, actionable value templates, and detailed value sheets for core social dimensions such as trust, safety, well-being, inclusivity, and building knowledge and skills. These elements were tested via interactions and input from SNS JU projects and external experts. To further validate these efforts, a workshop was designed and conducted with public Protection and Disaster Relief (PPDR) stakeholders, demonstrating the contextual and interconnected nature of values and identifying key socio-technical enablers. The framework provides operational recommendations to harmonise definitions and build multi-disciplinary expertise across the SNS JU ecosystem, ensuring 6G serves the collective interest and informs future EU research and innovation policy.

Keywords 6G, Key Value Indicators, social sustainability, responsible innovation, stakeholder engagement

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EXECUTIVE SUMMARY

The 6G4Society project addresses a fundamental challenge: ensuring that 6G networks deliver societal value alongside technical performance. This requires embedding social, ethical, and environmental considerations into infrastructure development from the beginning, rather than treating them as afterthoughts. The community has been working to do this via Key Value Indicators (KVIs). Over the last two years, the project worked with and gathered data across the SNS JU projects, consulted external stakeholders, and revisited the literature to understand the challenges and possibilities of building a framework for KVIs that could be used across all SNS JU projects.

The framework centres on KVIs, which differ from traditional Key Performance Indicators (KPIs) in important ways. While KPIs measure technical efficiency and operational standards, KVIs track actual and potential outcomes and impacts experienced by stakeholders. KVIs are reflexive and long-term, assessing whether technology achieves its broader purpose, such as reducing social isolation or improving accessibility. Beyond immediate implementation, the framework proposes moving from KVIs to Key Sustainability Indicators (KSIs) that assess long-term systemic change in a holistic way. KSIs evaluate whether current trajectories align with sustainability goals over time. This requires assessing interconnections, where values influence each other, and trade-offs, such as between energy efficiency and hardware requirements, and establishing governance for ongoing evaluation and learning.

The framework makes four main contributions. First, it provides conceptual clarity by distinguishing KVIs from KPIs and user experience metrics, ensuring indicators remain decision relevant. Second, it builds a definition of social sustainability and uses participatory methods to develop Key Value definitions with stakeholders across the SNS JU community. Third, it provides actionable process and template for defining a good KVI, that map stakeholder needs to technical choices, embedding values into design processes. Fourth, it presents the principles behind KSIs and delves into a detailed example of how these expand KVIs and what addressing interconnection could look like. Across it all, it provides exemplar KVIs and KSIs, to help ground the discussion in real examples and set the stage for future consensus about what KVIs should look like, what KVIs monitor in relation to 6G innovation, what kinds of decisions should be made with them, and who should be involved in defining them.

To complement this, a study with Public Protection and Disaster Relief (PPDR) practitioners demonstrated how this works in practice. This community was engaged to not just understand value definitions and monitoring potential from a stakeholder perspective, the process used was developed to be accessible and usable by others and in other verticals in order to continue to build this knowledge base and improve the legitimacy of the KVIs prioritized. The results showed that values shift with context, in emergencies, e.g. quality of life means basic survival rather than general well-being. It also revealed that values like safety, resilience, and trust are deeply interconnected, making isolated approaches ineffective. The study identified socio-technical enablers such as interoperability and shared situational awareness as critical prerequisites for achieving value-based outcomes.

The report finished with a series of recommendations to improve the operationalization and governance of KVIs. First, develop common definitions for values and sustainability across the SNS JU ecosystem. Second, build multi-disciplinary teams that combine technical expertise with social science and economic perspectives. Third, integrate KVIs from project inception to guide architectural and use-case decisions. Fourth, apply these learnings to inform EU research and innovation policy to advance both economic competitiveness and societal resilience.

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ABBREVIATIONS

4G	Fourth Generation (mobile network technology)
5G	Fifth Generation (mobile network technology)
6G	Sixth Generation (mobile network technology)
AI	Artificial Intelligence
CSA	Coordination and Support Action
DRR	Disaster Risk Reduction
EU	European Union
ICT	Information and Communication Technologies
KPI	Key Performance Indicator
KSI	Key Sustainability Indicator(s)
KV	Key Value
KVI	Key Value Indicator(s)
NGO	Non-Governmental Organization
NTN	Non-Terrestrial Networks
OECD	Organisation for Economic Co-operation and Development
PPDR	Public Protection and Disaster Relief
QoE	Quality of Experience
QoS	Quality of Service
R&I	Research and Innovation
SDG	Sustainable Development Goals
SNS	Smart Networks and Services
SNS JU	Smart Networks and Services Joint Undertaking
SRL	Societal Readiness Levels
TF	Task Force
TRL	Technology Readiness Levels
UX	User Experience

1. INTRODUCTION: UNDERSTANDING VALUE-DRIVEN INNOVATION

1.1. THE IMPERATIVE FOR A VALUE-DRIVEN 6G

To steer 6G innovation effectively, the SNS community seeks to establish a common strategic language and practice that embeds value and sustainability as core to 6G innovation. To create a more inclusive, sustainable, and human-centric digital future, the development of 6G technology aims to be guided by more than the pursuit of technical performance. It seeks to develop a deliberate and structured integration of societal needs, ethical principles, and environmental considerations from the very beginning.

This approach is central to the activities of the 6G4Society project, which worked to support the embedding of societal, ethical, and environmental considerations into the design and deployment of 6G infrastructure. By moving 6G “success” beyond a purely technological focus and evaluation, 6G development can proactively address critical societal challenges and align with long-term sustainability goals.

Values operate on two interconnected levels in innovation contexts. There are the *principles* and priorities people hold important, that motivate action and shape aspirations towards specific outcomes. This is the aspect of societal values that drive the choices made behind innovation: why this technology, why this audience, why this outcome being sought, why now, why here. There are also the *impacts*, the achievements or results that reflect those underlying principles. These are the desired changes made by innovation, what those innovating want to make better in the world. Combined, these create a value system that guides activities, including innovation, within society.

While European or industry value frameworks provide broad directional guidance, they must be adapted to organizational, domain, and project levels to become actionable. This requires moving beyond abstract principles to understand how values actually operate within specific use contexts and everyday technological practices.

Methodologically, this involves combining empirical analysis, normative assessment, and technological considerations. Approaches include analysing decision contexts, eliciting and representing stakeholder values, and facilitating co-design processes with impacted people. Scenario construction and systems mapping, identify key factors and their relationships, can illuminate pathways toward achieving value-related goals. **The goal is establishing values both as criteria guiding innovation decisions and as measurable outcomes resulting from those innovations.**

Key Value Indicators (KVIs) can contribute to this emerging research direction by offering methods that both elicit values and ground them in agreed-upon definitions and measurable indicators, enabling assessment of how values play out in practice, for whom, and with what real-world implications. But to do this, these agreed-upon definitions and the purposes of the indicators need to be established. **High-level principles do not automatically translate into practice. For example, fairness can be equal resources or equal ability to act. Each which suggest drastically different indicators to monitor. Translation requires negotiation, reflection, and transparency.** This also requires defining and validating the mapping logic that connects technical infrastructure capabilities to these societal outcomes.

This approach aligns with the concept of Societal Readiness Levels (SRL), which offer a maturity scale to track both the technology’s integration into society and society’s capacity to benefit from it, providing a structured pathway for monitoring and validating maturity beyond purely technical milestones.

Social Sustainability, in addition, goes one step further, placing values into a holistic frame that requires an approach that considers **relationships, dimensions, taking into account both present and future impacts**. Sustainability indicators, thus, require additional considerations and processes.

This deliverable sets the stage for a framework that offers guidance and structure to projects working on 6G, and ICT in general, to identify priority values and translate them into measurable indicators that both guide and evaluate technology design from the outset. It builds upon the foundational work of Key Value Indicators (KVIs), literature on Sustainability indicators, and ongoing work with SNS JU projects.

This is the first step towards:

- Building consensus on the aim and ends of KVIs, in order to create a set of prioritisation criteria;
- Building a stakeholder-relevant Key Value Frame to work within;
- Defining the criteria of a good indicator, including what data or evidence are best suited for the outcome; and
- Establishing the link between KVIs and sustainability, with a specific focus on social sustainability.

1.2. METHODS

The results presented in this report are grounded in a multi-modal methodological approach that bridges the gap between high-level societal values and technical 6G implementation. The methods balanced desk research, collaborative work with SNS JU project, engagement with external experts, and testing of proposed templates and processes.

The framework was populated and validated through a comprehensive set of engagement activities conducted between 2024 and 2025. This began with blanket surveys of ongoing SNS JU projects across Calls 1, 2, and 3, resulting in 63 eligible responses. These surveys captured current narratives on 6G societal impact and identified the existing landscape of KVI work to avoid duplication of efforts. This broad data collection was supplemented by focused consultation activities and small-group sessions involving a select sample of projects. These sessions explored how specific sustainability objectives relate to different project types and their implications for network design. Furthermore, joint workshops and webinars were organized with external experts and projects, to elicit challenges and solutions from the community. The insights were integrated into official 6G-IA Working Groups and the SNS JU Sustainability Task Force, both as input and for feedback. These contributions ensured that the framework elements developed here are built upon and the seeds for them are embedded into the broader SNS community.

At the core of this work are four primary contributions designed to operationalize values and sustainability within research and innovation, explore the potential of harmonized processes, build improved discourse around KVIs, and understand, through the discussion of concrete actions, what could really be of value to the community. This included:

1. Conceptual Clarification: “What is a Good KVI”

A central challenge in 6G development is distinguishing societal values from technical performance. The framework adopted here utilizes a structured guidance model that differentiates KVIs from KPIs and User Experience (UX) metrics. This ensures that indicators are not merely descriptive but are “decision-relevant,” directly informing design and governance choices. This work was reviewed and contributed to by 14 SNS JU projects as well as draws upon the insights of external experts and key literature in the area.

2. Stakeholder-Driven Value Mapping

Rather than relying on abstract assumptions, the framework proposes a process for stakeholder value mapping based in participatory and design thinking methodologies. By engaging with vertical sectors, such as Public Protection and Disaster Relief (PPDR), real-world scenarios and experiences can be used to co-create value definitions. This ensures that the resulting indicators reflect the practical constraints and priorities of those who will use and be impacted by 6G technologies. This process was designed and tested with the PPDR community, eliciting not only value definitions, but key interconnections, enablers, how they change depending on context, and key features for monitoring such values in that domain. Three projects supported in providing examples and explanation of KVI for a community that had never been exposed to the concept before.

3. Social Sustainability Value Sheets

To harmonize how values are interpreted across different projects, core dimensions of social sustainability were further elaborated with the active support of 8 SNS JU projects as well as both drawing upon the methods and KVIs in SNS JU project deliverables as well as key literature on the values. Five core dimensions have sheets developed which can be found in Appendix 1: Inclusivity, Well-being, Trust, Safety, and Building Knowledge & Skill. These sheets provide structured definitions and KVI exemplars, enabling a shared language for assessing impact and navigating the inevitable trade-offs between technical goals (e.g., speed) and societal goals (e.g., affordability or energy consumption). The sheet is being further explored within the working groups as a possible way to support further value clarification and harmonization.

4. Actionable Value Template

To bridge the gap between high-level principles and technical implementation, a structured value template was created. It was reviewed and commented on by SNS projects. This tool maps stakeholders and pain points to specific technology choices and decisions. This process ensures that KVIs are embedded within the decision pathway within the project rather than treated as an after-the-fact evaluation. In addition to being a way to define values and indicators as a group, it was tested and refined using Sustain-6G's and RIGOROUS' use cases to see how it could act as a guiding activity to support building concrete links between impacts sought, technology engaged, and indicators monitored. They are currently very much focused on social sustainability and need further expanding for the development of broader sustainability indicators.

By combining these structured tools with continuous community engagement, the methodology ensures that the findings in this report represent a consensus-based vision of success: a balance between technical excellence and the societal values 6G is intended to serve.

1.3. OUTLINE THE REPORT

Chapter 2 defines and examines the role of Key Value Indicators (KVIs). It provides foundational definitions for societal value and social sustainability. It then assesses the current landscape of KVIs within the SNS JU ecosystem, exploring the collective aspirations and practical hurdles projects face when attempting to operationalise these concepts

Chapter 3 transitions into practical guidance on working with KVIs, outlining the principles of robust indicator design, and proposing a structured, iterative process for building them.

Chapter 4 illustrates a process for eliciting and defining Key Values and how to monitor for them with stakeholders. It describes the methods behind a workshop to this end, that was conducted with Public Protection and Disaster Relief (PPDR) stakeholders, where the collaborative activities were able to ground abstract values in the operational realities of a

specific stakeholder community. It also presents the results: key value definitions, priorities, interlinkages, and proto-indicators that are stakeholder and vertical relevant.

Chapter 5 then expands from societal value to social sustainability, proposing a set of principles for shifting KVIs to address sustainability, introducing Key Sustainability Indicators (KSIs). It elaborates a proposal for a six-step framework, with examples, to transition from immediate value snapshots to long-term, systemic sustainability assessments.

Finally, **chapter 6** concludes with future directions and strategic recommendations, focusing on harmonising definitions, building multi-disciplinary capabilities, and informing future policy and funding frameworks to ensure 6G delivers meaningful and equitable societal impact.

1.4. ACKNOWLEDGEMENT

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In this context, we would particularly like to thank these projects for taking the time to provide feedback on the KVI, KSI, and value sheets, and taking a leading role to present and share their activities at the workshops” **6G-Path, TrialsNet, Hexa-X-II, Sustain-6G, FIDAL, Deterministic6G, Origami, 6G-Shine, Unity-6G, Rigorous, 6G-Leader, Flecon-6G, 6G-Versus, OPTI-6G, MARE, NEXA-Sphere, Multi-X, Ambient-6G, CENTRIC, 6G-Musical, 6G-INTENSE, TeraGreen, SAFE-6G, 6G-Bricks, and SUNRISE-6G**. The input, insights, discussions, and time have been invaluable to these results.

2. THE ROLE OF KEY VALUE INDICATORS

2.1. WHY PAY ATTENTION TO SOCIETAL VALUES WHEN WORKING IN 6G?

Traditional assessment models have often been constrained by three characteristics: they tend to emphasize incremental improvements within established paradigms, focus primarily on technical performance metrics, and struggle to effectively bridge the gap between measurement and decision-making around societal outcomes [1]. Without intentionally embedding social values into 6G projects, there's a risk of repeating these patterns, of developing technically sophisticated systems that do not fully earn public trust, may inadvertently widen existing gaps, or miss opportunities to address the challenges communities most need solved. Neglecting social dimensions risks public rejection, regulatory friction, and infrastructure project failure [2].

By orienting toward long-term sustainability outcomes rather than solely short-term technical metrics [3] [4], 6G initiatives can draw on insights from social sciences and humanities to reframe fundamental design questions in ways that foster innovation communities genuinely trust, adopt, and benefit from [5]. Key Value Indicators (KVIs) offer a practical framework for making this orientation tangible and actionable.

Societal value is fundamentally contingent upon context: what is considered a positive impact is not universal across groups, places, or time. The perceived value of a technology varies depending on the perspectives of those engaging with it and the specific environments in which it is deployed [6]. Impact is shaped by a community's social structure, political economy, and environmental conditions, which are often not made visible by easily quantifiable metrics [7]. Simple metrics often miss these dynamics. What benefits one group may harm another, which means evaluation frameworks must account for these differences rather than applying universal standards [8]. Assessment models that ignore local contexts and values risk becoming disconnected from the communities they're meant to serve [9].

Focusing on societal values ensures technology development responds to what genuinely matters to affected communities. This means measuring significant changes while being honest about what can and cannot be claimed [10]. It requires capturing both material impacts, like economic opportunities, and immaterial values like ethics, justice, and mutual support that quantifiable metrics often miss but that determine whether outcomes are truly sustainable [7].

Making values operational requires proactive indicators that inform design decisions before deployment, not just reactive tools that assess outcomes afterwards [11]. Shared values must guide innovation from the earliest design stages, moving from broad aspirations like inclusivity to concrete objectives that track tangible community-level change and connect directly to decisions developers and policymakers can actually make [12]. This demands analysing impacts across individual, regional, and systemic scales [13], and innovating beyond traditional statistics to include participatory methods, disaggregated data that captures marginalized experiences, and information formats accessible to those who will act on them [14].

Establishing baseline data about existing social conditions makes subsequent change visible and measurable [9]. This can draw upon mix of approaches like qualitative field studies, desktop research, and population data. The validity of these indicators and approaches comes from their context and their alignment with established frameworks, such as:

- **Sustainability:** Evaluating a technology's "handprint" alongside its "footprint" and related activities of the EU Green Deal and building on the lesson of developing indicators for the SDGs [15].
- **Rights-Based Governance:** Reflecting protections enshrined in the EU Charter of Fundamental Rights.

- Resilience: Assessing contributions to social resilience in alignment with the Sendai Framework and Aarhus Convention.

But to steer toward positive impacts, monitoring and evaluation must do more than measure technology: they must inform action and help navigate difficult trade-offs in complex systems. This requires looking beyond technologies as standalone to the broader digital ecosystems and societal structures. Evaluation processes should be transparent about systemic inequities, not as criticism but to clarify what claims can responsibly be made [16]. Methodologically, this necessitates a dual-layered approach: combining quantitative data for scale and qualitative insights for depth [12] [17]. Most importantly, evaluation must be participatory and inclusive, positioning communities as active partners, central in shaping change rather than just subjects of measurement [1] [18].

Equally important is distinguishing between outputs and outcomes. Value should be measured in relation to the importance of actual change to be experienced by stakeholders, not just the activities that might lead to change [19]. A training course is not the same as someone securing a job, even though one often leads to the other. The connections between specific outputs and their intended outcomes must be clearly documented and explained. This transparency allows stakeholders to understand the assumptions being made and enables continuous assessment as the technology develops [19].

By redefining success not by the speed of a technology, but by the benefit it brings to society, social value-driven design ensures that technological advancement serves the collective interest. The framework presented in this report seeks to support this by providing a set of tools for assessing the impact during the innovation phase, before the technology is fully deployed [20] [21].

2.2. WHAT IS SOCIETAL VALUE AND SOCIAL SUSTAINABILITY

Social Sustainability: A Critical Pillar of Holistic Development

Social sustainability is one of three core, interdependent components of holistic sustainability, alongside environmental and economic dimensions. It is rooted in social justice, human rights, and community well-being. Overall, it represents the capacity of a society to maintain the well-being of its members, ensure the stability of its democratic and social institutions, and maintain and enhance the social capital and cohesion required for members to flourish over time [2] [22].

Within European policy and development, Social Sustainability is viewed as the principle of safeguarding social options for the future, providing resilience in a way that ensures that present activities do not limit or harm future generations [23] [24]. It often centres on ensuring a just transition, as articulated in the European Green Deal through the Just Transition mechanism which asserts that environmental goals cannot be met if social equity is compromised. It also relates to The European Pillar of Social Rights and Corporate Sustainability Due Diligence Directive. Within NGO and non-profit sectors, the concept often emphasizes empowerment and individual agency in decision-making processes [25]. From a systems perspective, it can be understood as the capacity to prosper amid change [26].

A primary challenge remains the fact that the social dimension is less well studied or defined in sustainability assessments than the other dimensions [24]. While environmental metrics are often quantitative, social phenomena such as well-being and trust are intangible and resist quantification. Measuring social sustainability is difficult because it involves combining different data types, such as predictive surveys that capture subjective feelings. Furthermore, it is often a practice to focus only on indicators a project can directly influence, meaning broader issues like social equity or access to employment may sometimes be excluded [27]. Yet, it often is the more qualitative elements that determine whether a policy or project is socially viable in the long term [27].

The following elements are often considered to constitute the foundations of Social Sustainability:

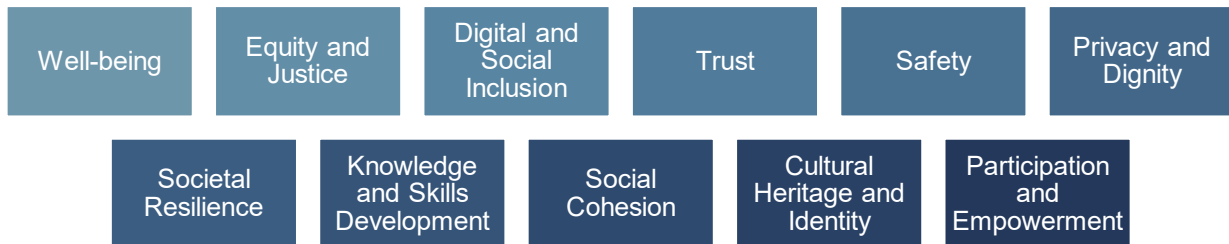


FIGURE 1 Key Elements of Social Sustainability

Throughout 6G4Society, five of these values were selected for further development (see Appendix 1). The selection drew on early project and policy analysis in D1.1 *Societal Aspects of 6G Technology*, balancing values frequently explored by projects with policy priorities that remained underdeveloped [3]. This focused approach allowed the project to validate both the process and content with the SNS community: establishing these value sheets as a credible references, guides, and foundations for consensus building. With the approach now proven, the next step is to develop reference sheets for the remaining values and continue a more formal consensus and prioritisation process.

Well-being: Encompasses physical and mental health, safety, and overall life satisfaction [28]. Well-being serves as both an outcome and a prerequisite for sustainable social systems. It is related to sufficiency, equity, quality of life, welfare, lack of poverty, social fulfilment and care, anxiety, creativity, work-life balance, health, loneliness, among others [23] [24]. It is further tied to autonomy and a calm physical and clean natural environment.

Equity and Justice: Social justice is generally considered to encompass three dimensions: a) Distributive Justice, the fair distribution of a project's benefits and burdens; b) Procedural Justice, the inclusion of stakeholders from the outset of any process; and c) Recognition Justice, respecting the rights and identities of marginalized population [29] [30]. Intergenerational justice is key towards this value as it relates to sustainability. It aims to ensure that vulnerable groups are not disproportionately burdened by policy shifts.

Digital and Social Inclusion: Inclusion ties directly to the above, to ensure equitable access to and benefits from resources and digital technologies regardless of location, age, disability, or socioeconomic status, so they may participate in society with agency and live with dignity [23]. It is about creating opportunities for all people in ways that address inequalities, ensuring people are listened and responded to, and empowering people to solve their own problems [31]. Key requirements include universal connectivity, digital literacy, affordable hardware, and accessible connections to essential services such as healthcare, education, and transport in remote or underserved areas [32]

Right to Disconnect: Conversely, it is also about the right to disconnect, and its connection to well-being, work-life balance, physical and mental health, which is particularly important in the age of hyperconnectivity [33]. This is the right to refrain from work-related communication during non-work times, a new societal value emerging in the last 20 years as a result of how technology has changed how people interact and their work environments and the increase of burnout and 'techno-stress' [34] [35]. This is tied to another objective of **decent work** [36].

Trust: Social sustainability is anchored in human rights, dignity, and (social and technological) system trustworthiness [37] [38] [39]. The degree to which community perceive authority figures, institutions, and technologies as credible, competent, and operating in their interest. Similarly, it is about how individuals and communities see each other as behaving credibly, transparently, and fairly. Trust operates as the foundation upon which all other social sustainability elements depend.

Safety: Society's ability to maintain critical social functions, protect the life and health of the citizens, and meet their basic requirements in a variety of stress situations. It is the protection from risk, be it environmental, social, or structural. It includes access to healthcare, housing, and social security [24]. It is about ensuring a reliable and sufficient social security system exists to provide basic human needs [22]. It is fundamentally about feeling safe.

Privacy and Dignity: Protecting individuals and communities from digital, social, physical, and psychological harm. Some frameworks put privacy under safety, as a means to achieve safety. Others have it as a fundamental right, regardless of whether it provides safety [40].

Societal Resilience: Refers to society's capacity to withstand and recover from external shocks including climate change and economic downturns [23]. Resilience is strengthened through diverse social networks, adaptive institutions, and the empowerment of communities to respond collectively to challenges. It can include mitigation, coping mechanisms, and strategies to create new systems or institutions.

Knowledge and Skills Development: The competencies required for individuals and institutions to effectively cope with and learn from crises and environmental changes. Sustainable societies must invest in human capital through inclusive education and lifelong learning to ensure both the current productivity and the long-term viability [2]. This ensures individuals possess the literacy and skills (digital, professional, democratic, cultural) necessary to navigate the world, bridging knowledge gaps and ensuring digital equity [31] [32].

Social Cohesion: This represents shared purpose and trust among different groups, and between citizens and authorities, creating a sense of belonging [41]. It is the collective strength of the community, networks of trust and reciprocity that maintain social fabrics, and acts as a buffer against system-wide shocks [42]. If individuals do not feel included or supported (in family, workplace, neighbourhood) broader societal sustainability goals are unlikely to succeed [43]. Social tensions can emerge from, for instance, fear of job loss, loneliness, political instability, and asset inequality [23].

Cultural Heritage and Identity: This encompasses cultural heritage preservation, fostering emotional and identity connections, and strengthening community resilience [44]. Cultural identity and heritage often serve as anchors for community cohesion and provide meaning and continuity across generations.

Participation and Empowerment: A critical element of social sustainability is active civic engagement and participation in decision-making processes [45]. Community engagement equips local governments with insights required to guide inclusive and responsive decision-making, strengthening trust between community members and elected officials while promoting buy-in for policy choices [46]. Empowerment extends beyond mere participation to encompass the genuine capacity of individuals and communities to shape their futures. This requires communities to possess both the voice and the capability to influence outcomes.

Interconnections with Other Sustainability Pillars

Environmental Integration: The European Green Deal's Just Transition framework demonstrates that environmental objectives cannot be achieved when social equity is compromised. Without adequate social support mechanisms, such as subsidies for low-income households, green policies including carbon taxes become politically vulnerable and risk public rejection. Ecological protection initiatives that create social hardship fail to secure long-term public support.

Economic Integration: While economic growth provides essential funding for social services, excessive focus on financial gain can erode the Trust and relationship upon which markets depend. A socially sustainable workforce characterized by health and education demonstrates inherently greater productivity and innovation. However, services must remain economically viable to achieve social inclusivity [32].

These form the basis for the Key Values under the Social Sustainability pillar. However, the SNS community must work with stakeholders, including verticals, communities impacted, and policy makers, to agree on which elements and outcomes are relevant and primary in different 6G contexts. This agreement should not be constrained by what can be standardized, since social values themselves cannot be standardized. Instead, the focus should be on achieving consensus around valuable outcomes that tie to visions of 6G and European success: improved skills, greater training opportunities, investment in underserved communities, or expanded service access for marginalized groups [47]. This requires clarity on the benefits people receive from these outcomes, which necessitates developing a long-term social value impact plan. Once the community reaches this agreement, the foundation for monitoring and evaluation becomes more clear.

2.3. WHAT IS A KVI?

Key Value Indicators (KVIs) represent a strategic shift in evaluation metrics, tracking how the technology is driven by and impacts societal values and improves the current status [48] [49]. The core purpose of KVIs is to guide and gauge the impact (both first and second order) resulting from emergent 6G technology in terms of **economic, social, and environmental outcomes**. It shifts the question from can technology perform to how will society change? KVIs are defined to measure the extent of **meaningful change** experienced by stakeholders resulting from an intervention.

A **Key Value Indicator (KVI)** is a qualitative assessment or quantitative metric used to observe the extent to which innovation (first order and second order effects) aligns with and furthers fundamental societal values. They focus on monitoring (and work towards validating) the impact of emerging 6G technology on the world they enter into.

Their goal is to move beyond evaluating project based on its outputs (e.g., what the project produces), for example, a demonstration of new technology in a testbed that could potentially offer 6G coverage in remote communities. Instead, KVIs aim to track outcome, which is the change experienced by stakeholders, such as 10,000 previously unconnected citizens gaining access to high-speed connectivity. While a project cannot measure this pre-deployment, it can measure this by proxies: features in technology and the contexts of deployment that are shown to support such outputs. While KPIs are feasible goals based on the technology, KVIs rely as well on other variables. KVIs might track back onto KPIs, but they can also track onto contextual details or processes that support the technology being successful. An example related to the **Key Value of Inclusion**, focusing on the objective **Leaving no one Behind**:

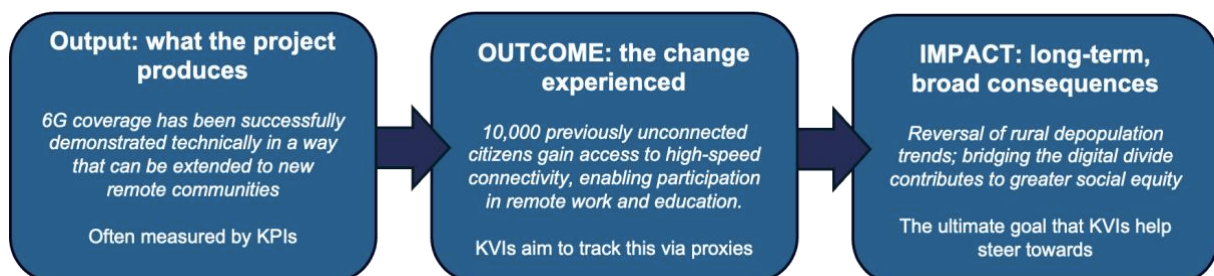


FIGURE 2 The flow between output, outcome, and impact

This distinction matters because projects often measure outputs (we trained 500 people) and assume outcomes (they got jobs), but the connection needs to be demonstrated or at least validated, not assumed. KVIs steer us toward long-term impact, like reversing rural depopulation or bridging the digital divides.

3. THE CURRENT LANDSCAPE: CHALLENGES AND ASPIRATIONS IN THE SNS JU ECOSYSTEM

Before charting the path forward, the current terrain was assessed. This chapter captures the collective perspective of SNS JU projects, drawing from workshop and survey findings to understand their aspirations and challenges regarding the implementation of Key Value Indicators. The insights reveal a community eager to align technological progress with societal good, yet acutely aware of the significant practical hurdles that lie ahead. Overall, the hopes and fears can be summarised as such:

Fears and Obstacles <ul style="list-style-type: none"> • Feeling that KVIs are too abstract and ambitious, to define, quantify, or qualify, especially at low TRLs. • Concern that sustainability goals will be sacrificed for market viability and cost. • Uncertainty about relationship between KVIs & KPIs. • Lack of in-house expertise to define meaningful indicators. • Risk KVIs become 'greenwashing' or box-ticking exercise. 	Hopes for KVIs <ul style="list-style-type: none"> • Foster responsible, sustainable, and human-centric innovation. • Align technology with societal needs and European priorities. • Balance technical and market requirements with broader societal goals. • Guide sustainable design and anticipate potential issues from the outset. • Increase social acceptance of 6G.
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TABLE 1 Fears and hopes for KVIs across SNS JU projects

3.1. THE VISION: HOPES FOR A VALUE-DRIVEN FUTURE

Projects consistently expressed a strong desire to use KVIs as a new pathway for aligning innovation with societal expectations. Their hopes are centred on fostering responsible, ethical innovation by making societal impact a primary consideration for developers.

These aspirations can be organized into five key themes:

Foster responsible, sustainable, and human-centric Innovation

- Guide the design of 6G technologies in a sustainable way and anticipate potential issues from the outset.
- Enhance innovation's capacity to address previously overlooked areas.

Projects want KVIs to guide the design of 6G technologies in a sustainable way and anticipate potential issues from the outset by integrating sustainable design from the beginning. The hope is that KVIs will allow the SNS community to engage societal expectations proactively instead of reactively. By using Key Value Indicators (KVIs) as a compass rather than just a ruler, developers can ensure that even at low Technology Readiness Levels (TRLs), design choices are driven by stated values and sustainability goals. They also want KVIs to enhance innovation's capacity to address previously overlooked areas, such as social equity or environmental regeneration, which are often neglected in purely market-driven development.

Align technology with societal needs and European priorities.

KVIs are envisioned to encourage responsible and ethical innovation that goes beyond technical performance. This involves shifting the focus from what a project generates (outputs) to why and for what purpose it creates value (reflexive approach). It encourages developers to consider European priorities alongside economic perspectives to ensure technology serves a

broader societal purpose. This would help ensure technology meets societal expectations and contributes to long-term value.

Balance technical and market requirements with broader societal goals.

There is a desire for KVis to support technology developers in focusing on societal needs, long-term benefits, and broad economic growth. Without a principles-based strategic framework like that which could be provided by KVis, technical and financial considerations (such as cost and latency) consistently override broader societal objectives. KVis are needed to help developers navigate these tensions by making trade-offs explicit and ensuring that market viability does not come at the expense of sustainability or inclusivity.

Guide sustainable design and anticipate potential issues from the outset.

KVis are envisions to support projects in addressing the needs and desires of people and the environment. This requires a shift towards a human-centric digital future where the human element, such as societal resilience and cooperation, is a primary design consideration rather than an afterthought to technical performance or merely a user requirement. They also want KVis to facilitate the replicability of beneficial impact across different contexts. By eventually identifying common KVis, a common KVI process, or shared value reference points, projects hope the impact can be scaled and adapted across different regions and verticals.

Align Technology Development with Societal Needs

Projects hope that KVis will support them in integrate the expertise needed into project teams, such as more social scientists and stakeholders, to broaden perspectives that support both anticipation of impact and understanding the context in which that impact should take place. Social scientists provide the expertise needed to engage with qualitative, non-technical data and help technologists understand how abstract values function in real-world contexts. External stakeholders support defining the problem and setting the scene from the earliest stages of a project. They also want KVis to support them in better engage directly with society through interactive design processes, by encouraging participatory approaches.

Increase Social Acceptance of 6G

Finally, it is hoped that KVis will boost work with stakeholders to align on core values, co-defining what meaningful progress looks like. This would make it easier to shift from a deficit model, where public concerns as dismissed as scientific illiteracy and instead build a trust-oriented, value-sensitive vision for 6G. The hope is that the use of KVis increase the likelihood of solution social acceptance by considering diverse viewpoints and by prioritising people and the environment.

3.2. FEARS, CONCERNS, AND PRACTICAL HURDLES

Alongside these high aspirations, SNS JU projects harbour significant concerns about the practical implementation of KVis. These challenges highlight the gap between the theoretical promise of value-driven innovation and the operational realities of technology development.

Feeling that KVis are too abstract and ambitious, to define, quantify, or qualify.

A central concern is the difficulty of measuring or defining targets for KVis, especially within a project's limited timeframe. There is significant uncertainty around how to define, apply, and quantify, or qualify KVis. This is particularly acute for projects at lower Technology Readiness Levels (TRLs), where direct impact is speculative. Many projects are unclear whether KVis should be measured during the project, after completion, or if they are focused on real-world impact that may take years to materialize. As one workshop participant noted, "the societal impact of the smartphone on children was not clear when it was being developed."

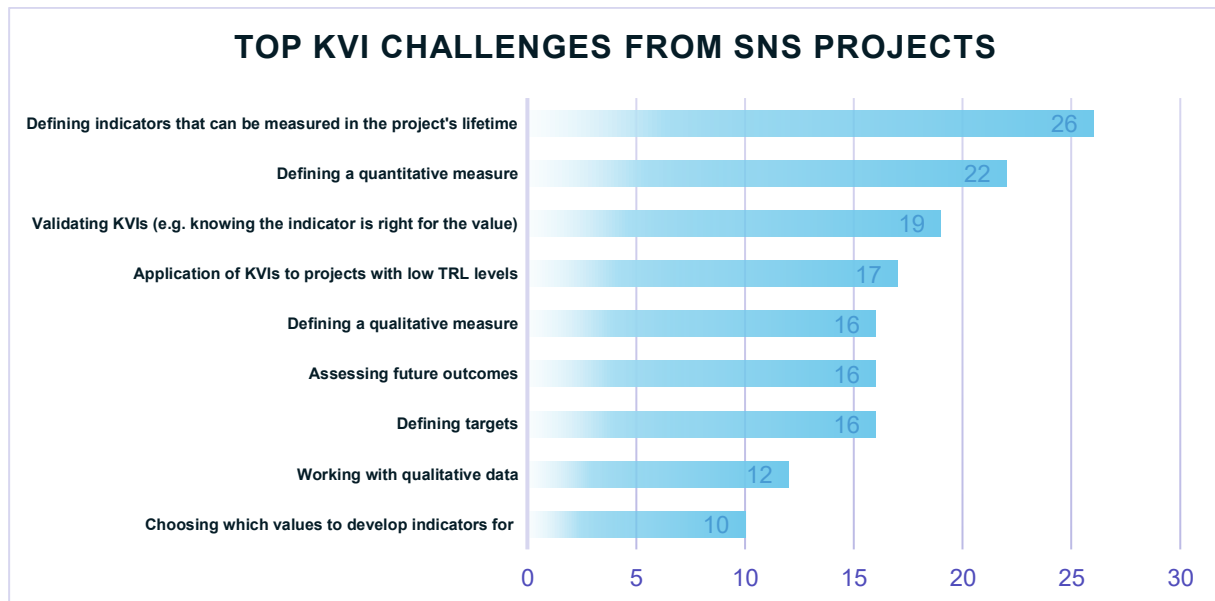


FIGURE 3 Top challenges as elaborated in survey of projects

Uncertainty about relationship between KVIs & KPIs

Projects struggle to map abstract KVIs to concrete Key Performance Indicators (KPIs). There is a widespread fear that such mapping may not be meaningful or easily validated. This uncertainty stems from the fact that KVIs are often perceived as too abstract for technology developers, which keeps discussions theoretical rather than actionable. This leads to a critical question voiced in the workshops: Are KVIs justifications for KPIs? Are they a way to prioritize KPIs? Or, should they be treated as something entirely different?

Lack of in-house expertise to define meaningful indicators

Many participants fear that their project teams lack the necessary multi-disciplinary expertise to define and measure KVIs properly. There is a recognized need for social scientists and other non-technical experts who can navigate the complexities of societal values, understand how they shift in different contexts, and often carry with them normative tensions. Furthermore, even when meaningful indicators are identified, projects may not have access to sufficient non-technical data to measure them effectively. This data often resides with external stakeholders like factory owners or healthcare providers, highlighting a gap between technical teams and the real-world contexts they aim to impact.

Risk KVIs become 'greenwashing' or box-ticking exercise

There is a worry that KVIs could become a tool for "greenwashing", used more as a marketing or reporting strategy than as a genuine driver of change. Participants expressed concern that claims made in project proposals may become disconnected from the actual work performed. If KVIs remain too subjective, complex, or intangible, they risk being used to justify existing KPI targets or falling out of use altogether, failing to live up to their sustainability promises.

Concern that sustainability goals will be sacrificed for market viability and cost

Perhaps the most important fear is the potential for trade-offs where social values or sustainability is sacrificed for performance or financial considerations. Many worry that industry decision-makers will prioritize market viability and cost, driven by industry KPIs, over sustainability goals. This can be currently seen in much of the end-goal of energy efficiency being to reduce cost rather than to improve the natural environment. This misalignment raises questions about the real-world relevance of KVIs. If industry decisions determine what comes to market, there are fears that KVIs will lack the authority or influence to shape the final product,

especially when values like privacy or inclusivity conflict with goals like energy efficiency or cost reduction.

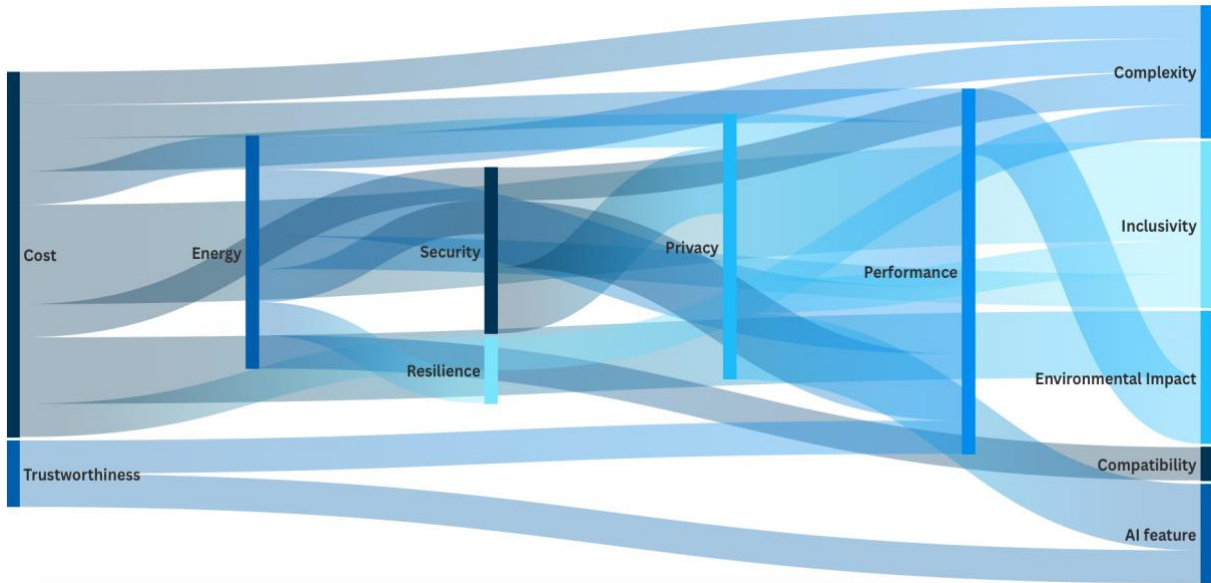


FIGURE 4 Trade-off relationships as express in project survey

But achieving societal goals is not a simple optimisation problem. Projects must constantly balance competing priorities. Project survey data reveals a complex network of trade-offs. Values like privacy, security and inclusivity are weighed against performance, cost, and energy efficiency. Cost considerations are traded off against nearly every other value. These tensions demonstrate that without a strategic framework, technical and financial considerations will consistently override broader societal objectives.

3.3. STRATEGIC QUESTIONS AND LESSON

The hopes and fears surrounding KVIs are shaped by a set of underlying, often conflicting, assumptions about what KVIs are and how they should function. These assumptions reveal a fundamental tension between viewing KVIs through a traditional, performance-oriented lens and seeing them as forward-looking enablers of long-term societal change.

Performance-Driven View (KVI as KPI)	Future-Oriented View (KVI as Enabler)	KVI as external to activities
<ul style="list-style-type: none"> - KVIs are to be mapped onto KPIs to evaluate during the project. - KVIs are measurable, objective, and need to be quantified. - KVIs have thresholds or targets to be met, similar to KPIs. - Quantitative measurements of KVIs are practically impossible 	<ul style="list-style-type: none"> - KVIs are enablers for something to unfold in the future. - KVIs are qualitative and subjective. - Indicators should not just be focused on engineering or technology. 	<ul style="list-style-type: none"> - KVIs represent factors that might not be present during a project’s lifetime. - KVIs point to changes in the world in the future. - KVIs do not always require empirical validation.

TABLE 2 Strategic challenges as expressed in project survey

This divergence raises a series of critical questions and lessons that projects are actively grappling with as they move from theory to practice.

1. **How to make abstract societal values be made tangible and actionable for technology developers?**

Many projects find it challenging to define societal impact when conversations are often limited to technical partners. There is a pressing need to bridge the gap between abstract values like “trust” or “well-being” and the concrete design choices made by engineers. Linking technology world value requires deep engagement with end-users, community groups, and policymakers. This requires **multi-disciplinary teams and new types of data** in order to define them consistently. It also requires an agreed upon structure to begin the harmonisation process, get assumptions on paper and out in the open, and support shared learning.

2. **What is the precise relationship between KVIs and KPIs, and can KVIs have measurable thresholds?**

There is a tendency to apply familiar KPI frameworks to KVIs, seeking quantifiable targets and thresholds. While the familiarity of KPIs makes it tempting to apply a similar logic to KVIs, many societal outcomes are not easily quantifiable with predefined targets. What percentage of stakeholders is needed to call something equitable or inclusive? How can trust between a person and a technology, which is an ongoing relationship, have a single static threshold target? It is not obvious how to measure thresholds for outcomes like saving lives, reducing household energy costs for marginalized communities, or improving a sense of community. **The approach needs to evolve to address the broader, multifaceted, qualitative nature of societal value and complex sustainability challenges.**

3. **How can the scope and ambition of KVIs be clearly defined to be both meaningful and manageable?**

Projects struggle to determine how far into the future KVIs should look. Should an indicator focus on the energy efficiency of a single component, or a broader goal like improving air quality five years after deployment? There is a need for a framework to manage the scope of KVIs, making them realistic and relevant without losing sight of long-term, large-scale impacts. This framework needs to support projects in making a KVIs purpose and decisions to be taken with the results of the indicator clear. **A KVIs true purpose is not just to provide data or describe a status but to inform a specific decision for a specific stakeholder towards a desired outcome.** If you can't act on it, it's not a good KVI.

Which values are the priorities and what are the objectives within them?

The community is addressing a wide range of values, from energy efficiency to security to democracy to inclusivity. **A common language, objectives, and reference points are needed** that enable cross-project learning and harmonisation. This needs to not just be common internally but common externally.

3.4. CURRENT KVI ENGAGEMENT WITHIN PROJECTS

Projects engage different KVI Pathway Validation approaches to validate the link between indicators, measures, and value. Some prove this link by demonstrating that the technical enabler directly drives a proximal outcome, which is logically and statistically tied to the distal goal. Others look for validation through user experience. Yet others seek to validate via bringing an index or combination of indicators toward a single value, creating a form of

triangulation. Some projects engage contextual aspects around a technology that support it reaching the ideal use, and thus the ideal impact, in the future.

Most projects currently evaluate their KVIs in large-scale trials. Many projects adopt a structured, iterative methodology originally established by the Hexa-X-II project and the 6G-IA Societal Needs and Value Creation (SNVC) working group. However, this methodology has been applied to mean a range of things and still leaves questions, including which values should be priorities, what is a valid link between indicator and value, and what an indicator technical looks like and how it should be used.

To make intangible values tangible, many projects use data-driven methods to link KVIs to technical Key Performance Indicators (KPIs), using KPIs as proxies for KVIs. In many of these cases, the KVIs are designed to be measured only after the innovation is deployed and in society, hence the need for technical proxies throughout the design process. Several projects move beyond technical specifications by engaging stakeholders directly.

Some projects are exploring if it is possible to have common KVIs across use cases that speak more to 6G generally, while others focus entirely on specific levels—some at the level of verticals, and some at the level of specific use cases. Some also see KVIs as pointing to social or economic features outside of the technology, while others see KVIs as a unique form of KPI, bound to technical metrics and thresholds to cross.

Projects assume a diversity of audiences for their KVIs, from internal project partners, policymakers, industry leaders, vertical stakeholders, users, to society in general.

Key Challenges

Many projects face a fundamental challenge in moving from user-centric design, focused on how individuals experience technology, to society-centric design that captures how systems transform broader social contexts.

KVI evaluation and validation often remains anchored in technical enablers and user experience measures, reflecting a structural limitation: as technology-focused initiatives, these projects typically lack the interdisciplinary expertise (sociologists, policy analysts, community researchers) needed to meaningfully operationalize and measure societal impact beyond current practices. Similarly, evaluation approaches are often tied to trials, either lab or field, thus leaving those without such processes built into their projects looking for ways assess value in technical design decisions. This gap highlights the difficulty of assessing systemic social change within projects primarily designed and staffed to advance technological innovation.

Moving Forward

Despite these challenges, as the SNS JU projects have been developing and exploring KVIs, there is a range of processes and elements considered as important to eliciting key values, objectives, and indicators. Some are highlighted below.

Multi-Dimensional Trade-Off Framework: SUSTAIN-6G [4] uses a multi-dimensional framework that engages in iterative loops between technology enablers and vertical use cases and stakeholders. The framework aims to make complex trade-offs transparent, such as the tension between reducing environmental impact and maintaining economic accessibility or high service reliability. It keeps its indicators focused on direct (first-order) effects while mapping them to indirect (second-order) effects. The methodology integrates participatory processes, acknowledging that what constitutes an acceptable trade-off depends on actor-specific constraints. It seeks to create a common language between technical developers and vertical stakeholders to ensure the network brings tangible societal value without unnecessary environmental impact.

Knowledge Graphs and Stakeholder Mapping: Hexa-X-II [21] uses a Knowledge Graph to map complex dependencies between enablers, design principles, and sustainability goals. From this graph, it selects the most effective technology mix for specific use cases based on

Human and Planetary Goals (HPG). This allows the project to visualize and evaluate thousands of possible combinations of technologies, dependencies, and requirements. Stakeholder mapping is used to characterize the business and social ecosystems emerging around 6G use cases, identifying the motivations, interests, and risks for every participant. This makes it possible to map handprints and footprints and, from those, derive what the project calls use case and enabler KVIs.

End-User and Business Model Decision Perspective: TARGET-X [50] [51] developed a Methodological Assessment Framework (MAF) that specifically adopts the perspective of the end-user (e.g., a factory manager) rather than the technology developer. The project evaluates use cases through two distinct lenses: Technical & Economic Perspective (KPIs) and Societal & Environmental Perspective (KVIs). The framework operates from the end-user perspective, such as production managers or site supervisors, treating every use case as a process centred on delivering a specific “product” (physical objects, services, or data streams). It uses User-KPIs to measure technical and economic outcomes and User-KVIs to quantify societal goals, bridging technical network performance with real-world business utility. Value propositions are categorized as explicit (immediate benefits like real-time safety alerts) or implicit (mid-to-long-term enablers), using KVIs to measure societal impacts and Life Cycle Assessment for ecological transparency.

Design-Thinking Approach: TrialsNet [52] grounds KVI elicitation in design thinking, but adds a mapping step to traditional processes to identify business and technology constraints before ideation. It employs Partial Least Squares Structural Equation Modelling (PLS-SEM) to statistically quantify the relationship between technical innovation and subjective variables like user acceptance. The methodology bridges the gap between network performance and human-centric value through a multi-step process integrated into the trial lifecycle: mapping KVIs to established Key Values; tailoring indicators specifically to vertical domains rather than using generic metrics; measuring value through both objective data (carbon footprint, energy savings) and subjective assessments (user acceptance, quality of life); and involving end-users and stakeholders early to co-define what constitutes value for each specific trial context.

User-Centric Pathways and Personas: ADRIOT-6G [53] [54] built their KVI process via a series of tools to create a pathway from technology enabler to societal outcome. The project employed the Arcadia Framework (user workshops to bridge between what the user wants and what the technology does), the Affinity for Technology Interaction (ATI) Scale (a psychometric tool to evaluate if a user is prone to interact with technology), and RACI Charts (to determine responsibility in a design ecosystem). The aim of this combination was to ensure governability of the system, with monitoring conducted via Proofs of Concept. In addition, the project used fictional user-centric value personas and persona-driven social pain points to represent specific stakeholder groups, explore attitudes, and ensure innovation benefits underserved communities. Their aim was for input from persona-based groups during the design phase to influence the innovation’s trajectory before it became rigid, and to shift focus from how it works to what it enables for the individual.

Sociological Multi-Layered Framework: In FIDAL [55] [56], KVIs are not just technical or user-based, but also examine the context around the technology, such as who is involved in the trials or how the trials relate to the desired market reach. After stakeholder identification to discover what people actually care about, the project uses paired socio-technological success metrics, tying together subjective social assessments and objective technological or social measures.

Mixed-Method and Consensus Validation: The 6G-PATH [57] [58] project used a three-phase methodology, beginning with a literature-based elicitation phase to map Key Value Enablers (KVEs) to specific goals within its verticals. This conceptual foundation was refined through a hybrid Delphi-Nominal Group Technique (NGT) involving cross-sector experts to finalize indicators. From these inputs, the project developed a unique Sustainability Trade-off Matrix to manage interdependencies between network performance and environmental

impact. To assess these values in trials, the project employs a mixed-method validation engine that correlates objective technical KPIs with subjective stakeholder feedback collected via semi-structured interviews and standardized psychometric instruments used by the verticals.

Societal Readiness Assessment: ECO-eNET [59] similarly divides first- and second-order sustainability impacts. It further supports its assessment of impact using Societal Readiness Level (SRL) assessments, alongside Technical Readiness Levels (TRLs), to track the acceptance status and deployment potential of specific 6G use cases. This allows the project to tailor the evaluation technique to be appropriate for the specifics of the use case as it evolves, such as shifting from low SRL where KVIs are more like high-level goals, to higher SRLs where they are closer to impact or value fulfilment.

Analogies and Expert Consultation: As part of its KVI evaluation, ENVELOPE [60] worked with expert consultations via methods like the Delphi Method, deductive reasoning, and comparisons with analogous cases to estimate long-term impact. The project also aimed, for each use case, to have at least one KVI per sustainability pillar.

Baseline Calibration and Phased Evaluation: 6G-SANDBOX [61] built a KVI approach that involves the calibration of a trial network, which involves measuring baseline performance to provide experimenters with the necessary context to interpret their results and understand how to compare between different testbeds. The project also engaged a phased approach where they started evaluating system and software KVIs prior to end-user perception KVIs. This allowed them to identify performance deltas, where change is caused by the introduction of a new component.

KVIs as Quantifiable Technical Properties: Many projects engage KVIs as directly part of their technology assessments. Examples include:

SAFE-6G [62] [63] established a unified Level of Trustworthiness (LoTw) score, which is an intelligent weighted combination of five distinct trust levels: Security, Privacy, Safety, Resilience, and Reliability. The project features an AI-powered chatbot that allows end-users to request these trust levels using natural language, which the system then quantifies into a technical score.

VERGE [64] [65] ties KVIs to technical enablers, requirements, architectural features, and use cases by analysing the factors that determine whether a use case will spread or be blocked, such as what will ensure service coverage or provide an attractive value proposition to the end user. This allows the project to map KVIs to KPIs for quantified estimates of KVIs, providing measurable targets.

RIGOUROUS [66] [67] approaches KVIs through a systematic process focused on privacy modelling which can be quantified and formalized. Its process is characterized by the use of declarative privacy manifests and a dual-source scoring system to quantify abstract values like privacy and trustworthiness. This manifest can be customized according to specific user preferences or varying regulatory standards across different jurisdictions.

Each project highlights unique elements in the development and application of KVIs, from bridging technical performance with human-centric value, to managing complex trade-offs, to operationalizing abstract concepts like trust and privacy. These diverse approaches reflect the experimental nature of KVI work and the difficulty of capturing societal impact within technology-focused initiatives. They also offer a breadth of the possible approaches that can be taken when working with KVIs, and that could be folded into a harmonised process.

However, a critical distinction must be made regarding the role of KVIs in this ecosystem. KVIs are not validation tools in the traditional sense. They do not prove that a use case is technically functional or that stakeholder demand exists. The frequent framing that “use cases will be validated with KVIs” conflates different forms of evidence and different questions. KVIs function as monitoring tools that track whether technology is moving toward its intended values, reveal emerging impacts during development, and expose gaps between intended and realized

outcomes. They indicate whether impact is reaching intended communities and identify when technical success is not translating to social benefit. In this sense, KVIs inform validation by providing evidence about value delivery and social outcomes, but they serve primarily as directional and diagnostic tools throughout the innovation lifecycle rather than as definitive proof points. Clarifying this distinction is essential to establishing realistic expectations for what KVIs can and should accomplish in the 6G development process.

3.5. WHAT THIS SUGGESTS ABOUT A FRAMEWORK

This background suggests that to transition from technical outputs to societal impact, a robust Key Value/Sustainability Indicator (KVI) framework must incorporate the following essential elements. Each addresses a critical gap in traditional assessment approaches and lays the foundation for the practical guidance provided in subsequent chapters.

1. Decision-Relevance & Actionability: A KVI's primary function is serving as a strategic compass, not a descriptive metric. Indicators must directly inform design, policy, or governance choices that help stakeholders navigate trade-offs between technical performance and societal goals. The guiding principle should be: "if you can't act on it, it's not a good KVI."

2. Stakeholder-Centric & Legitimate Design: Legitimacy emerges when frameworks ground themselves in real-world priorities alongside policy imperatives. This requires co-defining indicators with those who will use or be impacted by 6G, addressing their specific needs and desired outcomes. Multi-disciplinary teams, including social scientists and economists, are essential for navigating the qualitative complexities of societal values.

3. Focus on Outcomes & Long-Term Impact: Attention should shift from outputs (project deliverables) to outcomes (actual changes for stakeholders). Since societal shifts often take years to manifest, anticipatory proxies, such as community engagement levels, barrier-removing technical features, or enabling contextual elements, signal whether a project is on the path toward long-term value. This needs to be tied to a validation protocol for the proxies, moving beyond mere stakeholder consensus in workshops to ensure construct validity and reliability. A rigorous framework must mandate correlation analysis against objective outcomes to avoid selection bias and groupthink, ensuring these metrics reflect actual business or societal reality rather than just internal agreement

4. Multi-Dimensional & Scalable Assessment: Capturing how value spreads requires layering KVIs across dimensions: technical capability, user capacity, collective benefits, and regional contexts. This multi-layered approach pairs with multi-methodological assessment, recognizing that some insights demand quantitative metrics while others require more nuanced qualitative approaches. These methods need not be invented from scratch. Validated assessment methodologies from social sciences, sustainability research, and impact evaluation already exist and should be adapted rather than reinvented.

5. Context Sensitivity & Reflexivity: Societal value is never universal; it depends entirely on deployment context. The framework must acknowledge that positive impact in one setting may differ dramatically in another, while reflexively tracking both intended benefits and potential negative consequences.

6. Temporal and Systemic Durability: Comprehensive social sustainability demands holistic assessment that balances societal, environmental, and economic pillars. This includes mapping trade-offs (such as tensions between energy efficiency and hardware requirements), identifying interdependencies, and respecting ecological limits while ensuring equitable distribution.

7. Harmonization & Common Language: Ensuring accountability across the 6G ecosystem requires harmonized strategic language that enables meaningful comparison, learning, and coordination between projects and stakeholders.

4. WORKING WITH KVIs

To realise this vision, 6G4Society has been working to establish the foundations for of a common framework. The aim is to propose clear, step-by-step guidance, harmonise priorities and meanings, and support cross-project learning. A harmonised process also creates validity to the endeavour, support both transparency and accountability. Such a framework should promote knowledge sharing, support flexible indicators adaptable to different Technology Readiness Levels (TRLs), balance use case-specific and general indicators, and identify points of alignment where goals like digital inclusivity, social resilience, and performance optimisation intersect.

4.1. WHAT MAKES A GOOD KVI

4.1.1. Key Values and KVIs

Key Values identify, at a high level, what a society cares about or what mission a project intends to fulfil. They are the fundamental ideals, motivations, and foundations for human action and social decision-making. They represent abstract concepts of and principles behind what is desirable for society to flourish, such as trust, inclusivity, social cohesion, and safety. They serve as the criteria and goals that guide research priorities, policy objectives, and the overall direction of technological progress. But they are not specific enough to articulate how it should be understood or what about it should be monitored. Key Values are often identified top-down from global frameworks like the United Nations Sustainable Development Goals (SDGs) or the European Green Deal. To be acted upon, they need to be broken down into specific objectives and grounded in context.

Key Value Indicators are the operational tools used to assess how well or effective an activity or technology (like 6G) is contributing to those Key Value. They are a specific articulation of a goal within that value, Context-specific and tied to specific projects, goals, or actions. If the Key Value is Safety, the KVI would more closely relate to, for example, perceived personal security as measured by stakeholder assessment. They are based on a detailed rationale for linking their data to outcome. Their aim is to answer to what extent value is driving a choice or being created by an activity. Their articulation should also explain why and for what purpose that value is being measured. They provide an evidence base for impact claims, helping to monitor, validate, and track outcomes such as ecological benefits, social gains, and negative impacts and harms.

Examples of potential KVIs related to the **Key Value: Inclusivity**.

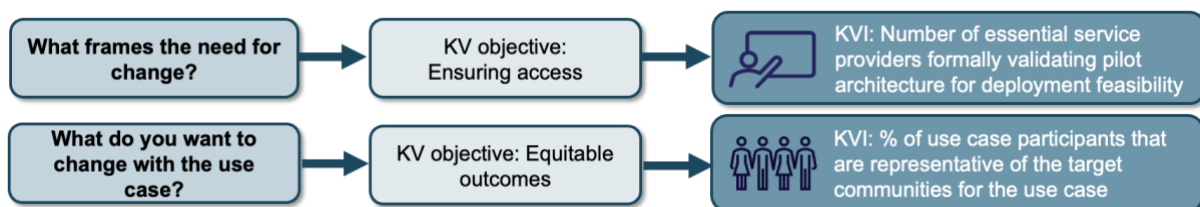


FIGURE 5 Key value, objective, and indicator relationship

4.1.2. The difference between KVI, KPI, and User Experience

KVIs, KPIs, and UX operate in tandem. KVIs operate alongside, but are distinct from, traditional Key Performance Indicators (KPIs) and User Experience (UX) metrics. While KPIs track operational efficiency and UX measures user satisfaction, KVIs assess the broader value delivered to society. Key Performance Indicators (KPIs) are typically performance-oriented, providing objective evidence of progress towards achieving a desired technical result. User

Experience (UX) indicators assess the quality and the experience perceived by the end user, providing evidence of how well a product or service meets user needs and expectations. Key Value Indicators (KVIs), in contrast, measure how a project creates and delivers social value, to users or broader stakeholders. Key differences include:

FEATURE	KPI	UX	KVI
FOCUS	Technical standards; monitoring operations and performance. Focus on defining standardisation.	Individual user's interaction with and experience of a technology. Relates to QoE.	Outcome in relation to key societal or sustainability values
TIME HORIZON	Short and medium-term focus, measuring real-time results, and within a project's lifetime.	Immediate to when user accesses the technology; based on the experience at that moment.	Long-term focus, reflecting what could emerge over time
APPROACH	Descriptive; answers "what" effectively the project generates.	Perceptual; answers how the user interacts with the product/service, the quality of interactions, usability, appeal, and satisfaction.	Reflexive; answers "why and for what purpose, and to what degree" the project creates value.
MEASURES	Quantitative and straightforward measures about technical results.	Multi-dimensional, quantitative, or qualitative, about how people feel about a product or service. Note: what one person values is not always representative of what a society values.	Multi-dimensional, quantitative, or qualitative assessments (using assessments, surveys, impact analysis) about proxies for outcomes.

TABLE 3 KPI vs UX vs KVI

KVIs define what value matters; KPIs quantify how performance enables it; UX describes an individual experience of that enabler.

If KPIs specify how efficiently a car is built, measuring its horsepower, fuel economy, and acceleration, then KVIs are the evidence showing the car achieves its societal purpose, such as safely transporting people, not contributing to city smog, increasing accessible transit for elderly citizens, or economic savings for families. The KVI ensures that even if the engine performs perfectly, the vehicle is taking society down the right road.

4.1.3. Principles of Robust KVI Design

A good KVI is an observable, concrete, and actionable translation of abstract societal values. These principles can be used to test and build KVIs.

- 1. Grounded in Legitimacy:** a KVI must be linked to a defined societal value, validated by a theoretical framework, and co-defined with affected stakeholders to reflect real-world priorities. This does not preclude drawing on existing standards, but selection of indicators should be justified in existing research.

Why it Matters: Avoids arbitrary selection and ensures the value being measured is meaningful and defensible. Early stakeholder engagement clarifies whose values the indicators represent, ensuring they guide decisions beyond technical performance.

2. Purpose Driven: When measuring the impact of a project, it is essential to clarify why you are measuring it in the first place. A KVI should define why measurement is needed and how results inform strategic decision-making. The purpose, scope, context, and questions the indicator aims to answer need to be defined upfront. This begins with articulating what success looks like, not just thresholds and targets, but the broader understanding that determines which factors matter and whether progress serves the project's intended purpose. Different purposes require different approaches: tracking progress to adapt implementation mid-project, evaluating outcomes for accountability, or establishing baselines for long-term monitoring each demand distinct measurement timelines and reporting structures. Purpose can be proactive or reactive, but must be explicit to avoid reducing value questions to purely technical concerns and to ensure all actors agree on what measurements actually mean.

Why it matters: Without clear purpose, indicators become disconnected from decisions. A KVI for end-of-project review is ineffective if ongoing strategic guidance is needed.

3. Outcome-Oriented & Actionable: a KVI focuses on change experienced by stakeholders (outcomes), not just technology delivered (outputs), and thus should support decisions that can be made as a result of its assessment. KVIs should assess the presence, scale, and significance of change and whether that change is meaningful to those affected. While this is not always easy to demonstrate, an indicator should still endeavour to serve as anticipatory proxies for outcomes exceeding a project's lifetime, establishing what level of change is necessary and desirable, and if action should be taken to get there. ***If you can't act on it, it's not a good KVI.***

Why it matters: Indicators should inform decisions along the pathway to impact, not just describe a current situation.

4. Credible: a KVI balances methodological rigor and practicality. Strong KVIs are:

- **Measurable:** Both quantitative (extent of change) and qualitative (explaining why change matters), using multiple data sources and types to strengthen interpretation. At lower-TRL, this may mean documenting design choices that enable future impact rather than measuring impact directly (e.g. demonstrating that architecture maintains accessibility across device types).
- **Feasible:** Realistic to collect within the project constraints (e.g. have access to, which means for lower TRL looking at contextual data beyond users), minimizing burden on stakeholders (e.g. avoiding overly long surveys). Should not attempt to measure societal impact (e.g., lives saved) which depends on external policy, real world deployment and adoption.
- **Strategic Proxies:** Measure the intermediate steps between your technical work and societal outcomes. It is not possible to measure "lives saved" in a pilot, but it is possible to measure whether responders get critical data faster in simulations or if the right partnerships exist for deployment, credible signals of future life-saving potential.
- **Accessible:** Understandable to non-experts, with clear links between indicators and values validated by affected stakeholders.
- **Clear:** in particular, about how change is defined. Against what benchmark, baseline, or condition? What scale and scope of change is being considered? Baselines can be drawn, for instance, from literature, comparable systems, or simulated scenarios. The aim is clarity about the reference points.

Why it matters: KVIs fail if data cannot be collected, if proxies don't credibly signal future impact, or if results cannot be understood or acted upon by the necessary decision-makers.

5. Reflexive: Explicitly tracks both potential positive and negative impacts, distinguishing between immediate effects (first-order) and longer-term transformations (second-order).

This also means **identifying potential negative and unintended outcomes and impacts**.

Why it matters: Encourages proactive management of unintended consequences and ensures that immediate gains (project outputs) build foundations for enduring impact.

4.1.4. Dimensions of Value Diffusion

KVIs can address values across different dimensions of scale and scope, from more first order impacts like those created by the outputs of the core technical system to second order impacts like that which affects societal change. Layering metrics across these dimensions will help create a credible, multi-dimensional proxy for a given outcome [21]. This draws upon and expands the stakeholder analysis dimensions established by HEXA-X-II. This one focused on elaborating the social dimensions. The HEXA-X-II provides details for all sustainability pillars, and extrapolation between pillars as to the dimensions is not a one-to-one process and needs further development going forward.

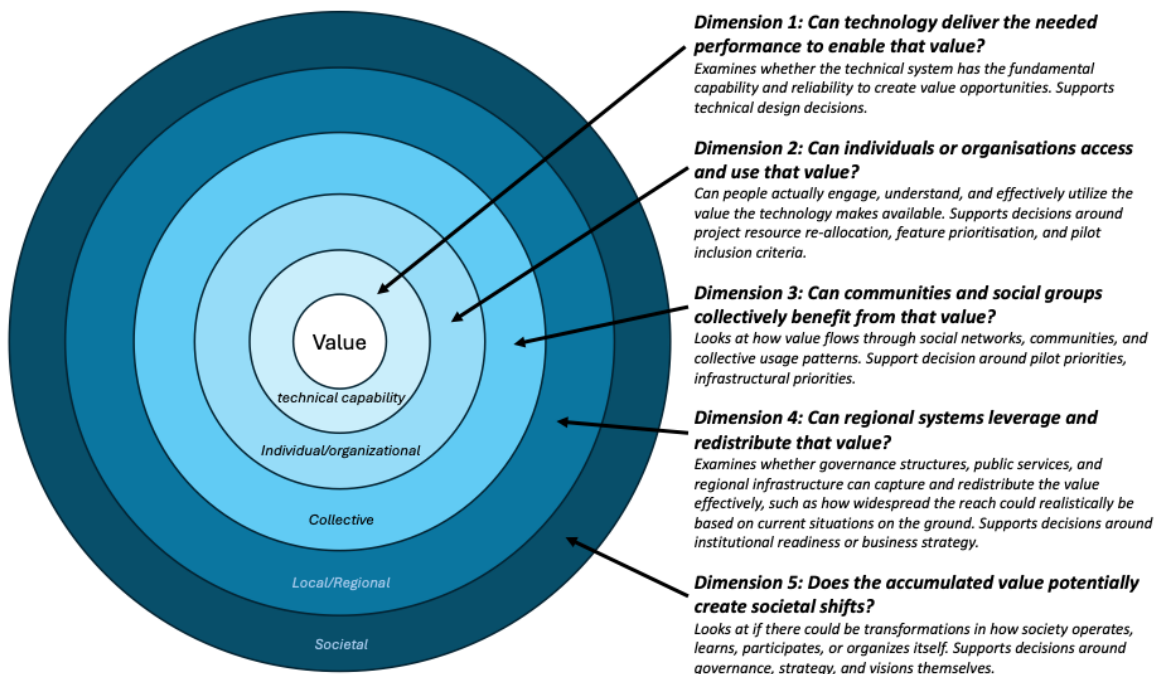


FIGURE 6 Different dimensions at which KVIs can operate

4.1.5. Practically, what does this mean?

While projects cannot verify the **ultimate impact** (e.g., reversing rural depopulation) or the **outcome** in the field (e.g., 10,000 new connections) because these effects often exceed the project's lifespan and rely on non-technical externalities like policy or user adoption. But projects can engage **anticipatory and measurement methods** validating perceived value **before** real-world consequences materialize.

A KVI methodology should rely on ex-ante indicators. These are indicators used to estimate and even quantify properties of a system before they materialise. Ex-ante assessment is a recognized practice across multiple fields including law, economics, engineering, foresight studies, innovation policy, and risk management to assess research and innovation. Methods include proxies, models, simulations, scenario analysis, among others.

That said, any forward-looking assessment must acknowledge its limitations and be transparent and acknowledge uncertainty. To help address this, though not alleviate this need,

KVIs should, when possible, use **multiple dimensions as credible proxies** that point to the desired outcome. Each dimension can also support different decisions/actions that can be taken as a result of the indicator. This involves identifying the specific achievements that must be met to make the outcome possible, including the social, economic, or environmental issues are most urgent to address to create a foundation for the connectivity to provide the benefit.

Example: What could a KVI look like?

Taking the example of building improved 6G access and related tools for use in emergency response in vulnerable, underserved areas, with the aim of with the aim of decreasing those not reached:

Dimension	KVI Example	Strategic Use (Decision Making)
D1: Can the technology deliver the needed performance to enable that value? <i>Examines fundamental capability</i>	<i>Network reliability:</i> in crisis conditions (e.g. simulated, percentage of emergency communications successfully transmitted in lab trials in high-density, emergency traffic scenarios)	Engineer making technical design decision: Does the technology meet the minimum reliability thresholds to be usable for life-saving communication in vulnerable regions to justify continued development?
D2: Can individuals or organisations access and use the value? <i>Focuses on user capacity and barriers.</i>	<i>Improved response times:</i> Reduction in time required for vulnerable populations (e.g., elderly, non-native speakers) to be located during a mock-disaster exercise, compared to baseline systems.	Product/service leadership prioritizing features: identify alternative or priority features that better align with the inclusion barriers identified. Shift activities from improving a device technically to identifying the training and support needs to improve adoption.
D3: Can communities and social groups collectively benefit from that value? <i>Looks at community, network effects, and collective usage patterns</i>	<i>Community Benefit:</i> Ratio of first responders and community response actors who could/could not be integrated into coordinated response networks in underserved areas with the proposed 6G technology vs. current connectivity limitations (demonstrated through network mapping exercises with local emergency managers).	Projects (industry and stakeholders) prioritising pilots: Which community groups or networks need to be prioritised to fill gaps in connectivity? (e.g. if the KVI shows poor performance in rural areas, then this indicates a need to prioritise such partnerships going forward and/or suggests the need for different bandwidth and processing priorities.)
D4: Can regional systems leverage and redistribute the value? <i>Considers if public services and regional infrastructure can capture value.</i>	<i>System compatibility:</i> Number of regional emergency management agencies whose existing communication systems are technically compatible (or require only minor adaptation) with the prototype's data formats and APIs.	Institutional Readiness Assessment: which regions have both the technical readiness and institutional willingness for meaningful pilots? What policy or standards recommendations should be put forward for success in the long run?
D5: Does the accumulated value create fundamental societal shifts? <i>Focuses on the highest level of long-term change.</i>	<i>Stakeholder Representation:</i> Evidence that historically excluded populations are systematically represented in project advisory structures, requirements gathering, design priority decisions, pilot selection criteria, or success metrics definition.	Strategic vision check (for project leads, funders): Is the project on track to fundamentally reduce the structural vulnerability of marginalized groups over the long term, moving beyond just providing temporary connectivity? Is the project's theory of change still accurate?

TABLE 4 explanation and examples for each dimension of KVIs

Each KVI should be able to reference a stakeholder, impact, decision combination.

While some KVIs can only be measured after project completion, such as lives saved through improved connectivity, relying solely on these is insufficient. This approach burdens future users with verifying promised values only after investing resources, and requires governance structures to ensure continuity across projects. Although long-term KVIs serve as valuable strategic objectives, they must be accompanied by real-time indicators that can steer the project during execution. Essentially, post-project KVIs represent end-user goals but within projects should function as overarching objectives that inform the selection of actionable short-term leading and lagging indicators for the project itself.

4.1.6. Validating the Proxies

Proxy indicators require rigorous validation of their value correlation links claimed, because they represent, rather than directly measure, the social values they claim to track. The gap between what can be easily measured (e.g., network coverage) and what actually matters (e.g., digital inclusion) introduces significant risk of construct validity failure or conflating the means for the end, where indicators systematically misrepresent the phenomena they purport to capture. Without validation, proxies can create misleading narratives: technical metrics may improve while social outcomes stagnate or even deteriorate. Validation protocols are needed to establish whether a proxy reliably correlates with its intended value across different contexts, populations, and time periods. This is particularly critical for 6G development, where the complexity of socio-technical systems means that assumed relationships between technical performance and social benefit may not hold in practice. Validated proxies enable evidence-based decision-making; unvalidated ones risk optimizing for metrics that do not meaningfully advance the social values the technology aims to serve.

4.2. HOW TO BUILD A GOOD KVI – A PROPOSAL

The KVI development process begins with mapping where indicators might apply within a project, whether influencing technology design, policy recommendations, pilot selection, or stakeholder engagement strategies. Rather than jumping directly to specific outcomes, this approach maps possible pathways from project activities to broader impact, including changes achievable within the project itself, from technology design decisions to consultation practices. These pathways contain the insights needed to identify meaningful KVIs.

This initial mapping considers whether the work pursues incremental or transformational change, identifies who or what might be affected (directly or indirectly), and clarifies the specific challenges being addressed, such as improved health outcomes, reduced pollution, equitable 6G impact, enhanced working conditions, strengthened community connections, or expanded economic opportunities. Strategic requirements from funding sources are also incorporated at this stage. The process should draw on existing policy, industry, or disciplinary roadmaps and research to reveal non-obvious links between project work and wider societal challenges. This review may surface pre-existing frameworks and indicators to build upon. Projects may also develop a brief impact pathway or theory of change (e.g. a simple outline or diagram showing anticipated steps from project work to broader outcomes) which supports future systems mapping essential for longer-term value and sustainability assessments.

Once this background is in place, the methodology guides projects from defining core values through to identifying measurement approaches. The process can be completed linearly or iteratively, with earlier steps revisited as thinking evolves. It involves:

- Defining the Key Value
- Breaking it down into Actionable Objectives
- Articulating affected stakeholders

- Describing positive and negative impacts
- Connecting value to technical work and use cases
- Building a foundation in background research
- Deriving indicators aligned with the previous elements

Flow of Activity Between Value and Indicator

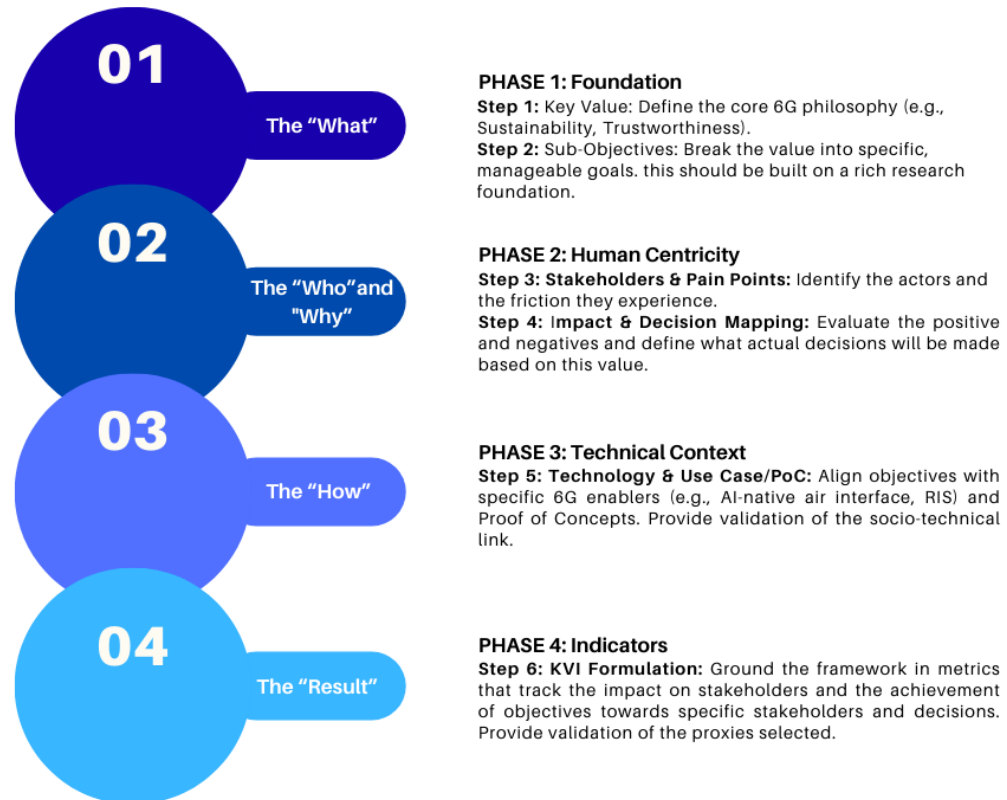


FIGURE 7 Flow of activity between value and indicator

This framework establishes foundations that make defining KVIs more manageable, drawing on challenges identified across projects and guidance from external experts and literature. It also supports the comparative work needed to find commonalities and harmonize approaches across multiple projects.

Ideally, the first steps should be done collaboratively across the SNS community to develop harmonized definitions, objectives, and priorities. In addition, the technology community and the vertical stakeholders should work together to articulate the objectives, which specific stakeholders matter for which kinds of use cases and which pain points or impact should be the focus. This should also be revisited regularly.

Examples of this process completed can be found in the Appendices, where they not only define the KVs and objectives, but carry through key concerns for 6G to provide exemplar KVIs.

Defining the Key Value

The proposed process begins by clarifying the core value being addressed. This establishes shared language and goals within the project team and with stakeholders, ensuring that subsequent objectives, indicators, and technical choices align with clearly defined societal, economic, or environmental benefits. In mature implementations, values may be pre-defined within a curated list relevant to 6G contexts.

The definition includes three components:

Pillar: The overarching category; Societal, Economic, or Environmental.

Key Value (KV): The specific value being addressed, such as 'Resilience' or 'Safety'.

Explanation of KV: A detailed definition that covers the value's scope, fundamental principles, and how it translates into tangible benefits or outcomes for society. This explanation includes citations indicating the source of the definition and which stakeholder perspectives informed it. The citations for the sources for this definition should be included.

Relevance to 6G: An explanation of why this value matters specifically for 6G development. For instance, for the more abstract value of Inclusivity, this could be describing risks of widening existing divides or creating new exclusions if the value is not prioritized from the outset. These explanations focus on 6G's impact on the world it enters, rather than on technical improvements alone.

Breaking Down Values into Sub-Objectives

The methodology translates abstract Key Values into specific sub-objectives. These are distinct, actionable goals that must be achieved to fulfil the overall value. Each sub-objective receives a short title and brief explanation, with as many sub-objectives defined as needed to provide clear direction for project activities. This helps turn abstract ambitions into practical goals. It is strengthened if defined in collaboration with stakeholders.

Identifying Affected Stakeholders and Challenges

The process then identifies who is affected and what challenges they face in relation to the defined objectives. This positions goals within real-world needs and determines whose perspectives should inform design, testing, and evaluation. This is where the process is in particular focused on societal value and social sustainability.

For each relevant stakeholder group, the methodology documents specific challenges or "pain points" that successful adoption of the Key Value would illuminate or help solve. Stakeholder categories might include individuals/end-users (with pain points related to accessibility, affordability, or digital skills gaps), among others relevant to the particular value being assessed.

Mapping Impacts Pathways

The process then maps potential impacts and decision pathways, showing how different stakeholders could benefit from or be disadvantaged by project outcomes. This step transforms abstract value statements into practical insight for accountability and risk management. Stakeholders here are both external and internal: individuals, end-users, community groups, organisations, governments, public sector, or technology developers and providers.

For each stakeholder group, the methodology describes potential positive and negative impacts within the Key Value framework. These impact descriptions consider:

- Scope of impact
- Significance of impact
- Whether impacts are first or second order in nature

This mapping helps envision success factors and the desired state if the project proceeds appropriately.

Clarifying Assessment Purpose and Decision Pathways

The methodology requires clarifying who will use the generated evidence and for what decisions. The intended users may represent a subset of identified stakeholders, as most stakeholders will likely receive value without actively making decisions based on indicators.

This step is fundamental to indicator design. Since indicators are intended to inform specific decisions by specific actors, the purpose must be clear before development begins. Different decision-makers require different assessment approaches, e.g., an indicator supporting an engineer's design change differs from one helping a marginalized end-user evaluate whether a technology will benefit them or enabling a funding body to assess impact.

This consideration extends beyond traditional use case or proof-of-concept mapping. While technical KPIs implicitly target engineers making design decisions, KVIs can inform a range of decisions across the different dimensions of value diffusion.

Connecting to Technology and Use Cases

The process connects sub-objectives to specific technologies under development and considers implications for use case planning. For each sub-objective, explain how it should influence the design and prioritization of details within 6G use cases or proofs of concept. This translation from societal aims to technical design choices articulates the rationale behind design priorities. For projects at very low Technology Readiness Levels focused on basic research without defined use cases, the approach articulates how the research could advance value-based activities more generally.

The process then identifies specific technological enablers, features, or architectural components most implicated by each sub-objective. This mapping connects key technology development activities to sub-objectives, articulating how different technological elements relate to the impact mapping from previous steps.

This step should, in the end, fundamentally change how use cases are described, with the value drivers and impact at the centre, and the technological choices there justified by the impact, not the other way around.

Developing Key Value Indicators (KVIs)

A KVI captures meaningful signals that activities are advancing intended societal, environmental, or economic value, not merely tracking performance metrics. The aim is making the link between technology development and value creation visible, credible, and actionable.

With stakeholders, objectives, and decision uses mapped, the basis now exists to begin translating values into measurable evidence.

The methodology should start by building a secondary research foundation (the primary one is the one that supports the value definitions, objectives, and pain points). This research foundation should focus on the specific combination of value, use case, stakeholder, and pain point in order to identify which solutions are highlighted by policy, which are important to communities, and where existing indicators or proxies might already be established. Building from such a foundation connects indicators to established and credible understandings of impact pathways, clarifying and articulating the rationale behind indicator selection and establishing which indicators need to be considered together.

KVI elicitation then begins by taking all this background and considering:

- What observable changes or signals would indicate progress toward the Key Value?
- Who needs to see that evidence, in what form, to make decisions?
- Should the indicator be measured to guide design or to demonstrate impact?

Each KVI should be able to directly address a stakeholder, impact/pain point, and support a specific decision.

Effective KVIs often combine measurable features (such as “percentage of underserved users gaining access”) with qualitative or contextual layers (such as “users report increased trust or autonomy”). Development may draw on existing frameworks (e.g. OECD well-being metrics, EU digital inclusion measures, Social Value International Indicators) to anchor KVIs in recognizable structures.

Each KVI should enable action: if no decision or adjustment can result from a KVI, it functions merely as a descriptive claim rather than an indicator.

The KVI process is designed to move beyond individual user needs by treating technology as part of a broader digital ecosystem and social structure. Because societal value is fundamentally contingent upon context, the actual impact of an innovation is shaped by the specific social structure, political economy, and environmental conditions of the area it enters. By using variations of systems mapping, stakeholder and scenario construction, the KVI framework makes it possible to identify the specific relationships between technological features and the structural barriers that might prevent them from achieving their intended purpose. This mapping process explicitly addresses contextual hurdles that are often invisible to purely technical metrics, such as insufficient organisational funds, lack of sustainable business models, inadequate standards, physical and demographic constraints, and missing voices.

This element of the KVI process identifies **socio-technical enablers**. These are the specific features related to society (such as policy recommendations, institutional readiness, infrastructure modifications, or kinds of stakeholders consulted) required for a technical feature to translate into a societal value. By identifying these context-specific nodes of activity, project teams can decide whether to refine the technology itself or to address the upstream structural barriers, such as advocating for broadband expansion funding or contributing to a standard, to ensure the technology can actually deliver its promised impact.

4.3. HOW CAN LOW-TRL PROJECTS WORK ON KVIs?

Currently, KVI are defined in relation to PoC and Use Cases. As the SNS JU community gathers evidence about the effectiveness of the current diversity of KVIs, this represents a vital first step. Once strategic decisions are made around the lessons learned from the early definitions and applications of KVIs, a more overarching list of KVIs can be articulated for 6G in general.

Even fundamental research or low-TRL can contribute to societal or sustainability goals. The purpose and manifestation of KVIs change significantly across maturity levels: at low-TRL they point projects in a direction, while at mid-TRL they focus more on measuring impact. Key to this is reframing the KVIs from an indicator of impact created to indicators of drivers of choices linked to intended impacts.

At low-TRL, there is no established methodology for embedding values early in the technical development process, which can make values discussions feel premature when researchers are focused on technical feasibility and foundational concepts. End-user engagement is typically minimal at this stage, with work happening in controlled or simulated environments. This creates a risk that value dimensions like privacy, sustainability, and inclusion get acknowledged superficially rather than meaningfully integrated.

Yet, low-TRL also offers great flexibility and opportunity to explore. KVIs at this stage should emphasize potential and enablers, guiding and representing early design decisions that link emerging technologies to future value areas. The heterogeneity of low-TRL projects (some demonstrating technical enablers, others exploring architectures) requires adaptable approaches rather than prescriptive frameworks. In essence, KVIs drive low-TRL projects by engaging Key Values as principles, whereas mid-TRL projects engage them as measurable outcomes.

KVIs at low-TRL therefore ask something different: “If we build this technology, what values must it uphold?” For instance, a project developing new spectrum-sharing algorithms might ask: ‘Does this design preserve equitable access for smaller operators, or does it advantage incumbents? Rather than traditional metrics, KVIs here can be based on documentary evidence, external expert consensus, or specifically identified proxies. For example, an architectural checklist of elements previously demonstrated to enable future value impacts, or an assessment of known enabling characteristics. If the Key Value is Digital Inclusion, the KVI might demonstrate feasibility of inclusive design through proxies, such as showing how the current design maintains performance even on devices with very low processing capability. Evaluation tools for these early stages remain limited, making integration into PoCs a significant design challenge. Qualitative and subjective assessments, including narratives, stakeholder interviews, experiments, and focus groups, become particularly valuable for exploring expectations, perceived benefits, and risks when quantitative measurement is not yet possible or appropriate.

4.4. LINKING KVIs TO SRLs

To support projects at all TRL levels identify appropriate KVIs, it is valuable to connect KVIs and Societal Readiness Levels (SRLs). The connection between KVIs and TRLs are already proposed in [68], though this needs further validation and grounding. However, SRLs add a different dimension of innovation, focusing on society’s ability to take on and benefit from a technology. KVIs and SRLs are interconnected tools that allow innovators to move beyond technical performance and ensure that technology is accepted by and adapted to society [69] [70] [71] [72] [73]. While SRLs offer a **maturity scale** to track the progress of societal integration, KVIs function as the **diagnostic and monitoring tools** that provide the evidence base needed to substantiate claims of readiness at each stage.

Linking KVIs to SRLs is essential because high technical performance (measured by Technology Readiness Levels (TRL) does not guarantee success if a solution is not trustworthy, accessible, or relevant to its intended users. This interconnection is important because:

1. **Operationalising Maturity Milestones:** SRL scales require innovators to identify societal readiness and validate impact as part of their progression. KVIs move these requirements from abstract principles to measurable outcomes, providing the specific data needed to justify moving from one level to the next.
2. **Directional Guidance throughout the Lifecycle:** KVIs act as a strategic compass that evolves with the project’s maturity. At lower SRLs (1–3), KVIs serve as guiding principles to drive early design choices; at higher SRLs (7–9), they transition into validated evidence of actual societal well-being and impact.
3. **Context-Sensitive Validation:** Societal value is fundamentally contingent upon context, and SRL assessments require testing in relevant environments. By linking KVIs to these stages, innovators can identify **socio-technical enablers**, such as policy alignment or community capacity, required for a technical feature to successfully deliver its promised societal benefit.
4. **Mitigating Innovation Failure:** Projects frequently reach TRL 9 (market-ready) while remaining at SRL 1 (isolated idea) resulting in technically perfect solutions that are

rejected by the public. KVIs ensure that the societal purpose is monitored alongside technical performance, preventing the waste of resources on non-acceptable innovations.

The following table demonstrates how KVIs are integrated into each stage of the Societal Readiness Level scale.

SRL Level	SRL Maturity Milestone	Role of KVIs / Interconnection
SRL 1	Identifying the problem and generic societal readiness aspects.	KVIs act as high-level prioritisation criteria . They define the intended “societal purpose” (e.g., safety, inclusivity) the project seeks to address.
SRL 2	Formulating the solution and potential impacts.	KVIs are anticipatory proxies . They establish what “success” looks like for identified stakeholders and set the baseline for future measurement.
SRL 3	Initial testing of proposed solution concepts with stakeholders.	KVIs measure perceived usefulness and gather initial stakeholder feedback to assess if the concept meets user needs in controlled environments.
SRL 4	Problem validation through pilot testing in a relevant environment.	KVIs track practicality and resistance . They provide the evidence needed to substantiate that the solution is ready for a “relevant environment” rather than just a lab.
SRL 5	Solution validation by relevant stakeholders in the area.	KVIs assess local alignment . They measure whether the solution addresses the specific “pain points” and diverse perspectives of the community it is entering.
SRL 6	Demonstration in relevant environments and in cooperation with stakeholders.	KVIs collect insights on potential impact . They use mixed-method validation (qualitative and quantitative) to see if the technology disrupts or supports everyday life.
SRL 7	Refinement of the project and/or solution.	KVIs identify unintended consequences or ethical hurdles. They ensure refinements are driven by values like privacy or equity rather than just performance.
SRL 8	Qualified solution and complete plan for societal adaptation.	KVIs validate the plan for societal adaptation . They provide a final evidence base showing the system is ready for adoption and adheres to long-term sustainability goals.
SRL 9	Actual solution proven in relevant environment.	KVIs measure actual outcomes and long-term impacts . They provide conclusive evidence of value delivery, such as “lives saved” or “bridged digital divides”.

5. FROM THEORY TO PRACTICE - A CASE STUDY IN THE PUBLIC PROTECTION AND DISASTER RELIEF (PPDR) VERTICAL

This section presents a case study in stakeholder engagement, used to establish a methodology for eliciting and defining values with stakeholders grounded participatory and design thinking methodologies. It demonstrates a concrete methodology for grounding abstract societal values in the operational realities of a specific vertical, translating high-level principles into actionable guidance for developing next-generation communication solutions.

The activities took place in a workshop jointly organized by 6G4Society and Public Safety Communication Europe (PSCE) with nearly 40 Public Protection and Disaster Relief (PPDR) practitioners, industry experts, and academics.

While this workshop serves to identify potential indicators, these candidates must undergo empirical testing and theoretical rigour to **confirm their construct validity and reliability**. Without moving beyond the workshop setting, the framework remains vulnerable to the echo chamber effect, where local consensus is mistaken for universal accuracy.

Three Key Insights emerged:

1. **Stakeholder perspective matters:** PPDR practitioners understand these values uniquely based on their goals and operational contexts. This guide captures their perspective to help align innovation with real-world needs. An important observation to note about this is that the core values here do not necessarily align with the core values being focused on by the SNS JU projects.
2. **Context fundamentally changes what values mean:** In a blackout, “quality of life” shifts from general well-being to keeping people alive. In wildfires, “trust” shifts from institutional trust to data reliability. Indicators must reflect these shifts.
3. **Values are interconnected, not isolated:** Working on Safety without Trust, or Resilience without Education, will be incomplete and less effective. What is interconnected likely changes depending on the vertical and stakeholder context. These types of activities can help reveal these links, making it easier for projects to select indicators, but also make them credible to the stakeholders being served.

5.1. TRANSLATING ABSTRACT VALUES INTO ACTIONABLE GUIDANCE

Methodology

This methodology was tested as the 6G4Society Workshop at the 2025 Spring PSCE Conference. This biannual conference serves as a platform for Public Safety Communication (PSCE) members and external stakeholders to gather and exchange information on important public safety communication topics. Attendees included expert representatives from industry, research institutions, and Public Protection and Disaster Relief (PPDR) practitioners from within and outside Europe.

The primary aim of the approach was to leverage PPDR expertise to help establish how the work being conducted within 6G4Society can support SNS JU projects in integrating values into their design and development processes. More practically, the workshop was focused on two things: 1) Better understand the alignment between the value-driven approaches pursued at the European project level and the needs of PPDR users; and 2) exploring the potential of such an approach to actually elicit values, priorities, definitions, and KVIs from an external stakeholder community that had previously never been introduced to the KVI concept.

The collaborative session was designed to leverage the knowledge and expertise of the PPDR community within PSCE to gather inputs and insights. By participating, first responders

contributed their expertise to shape 6G innovations. Around 40 stakeholders participated in the workshop.

Workshop Procedure

The collaborative session was structured into four main parts. The total time allotted for the formal activities was approximately 2.5 hours. All activities at the tables were recorded for data analysis. Participants were also provided with large paper sheets, sticky notes, and markers to map out their thought processes.



Framework Presentations: Three selected projects from the SNS JU community (e.g., FIDAL, TrialsNet, 6G-Path) presented examples of value-driven innovation for PPDR use cases to provide context. These presentations covered a brief introduction of the projects, their approaches to value integration into project activities, specific examples of KVs, as well as how they see KVs being used by the stakeholder community.

Interactive Activities: Activity introduction and group formation, participants were gathered to engaged in collaborative activities over four steps.

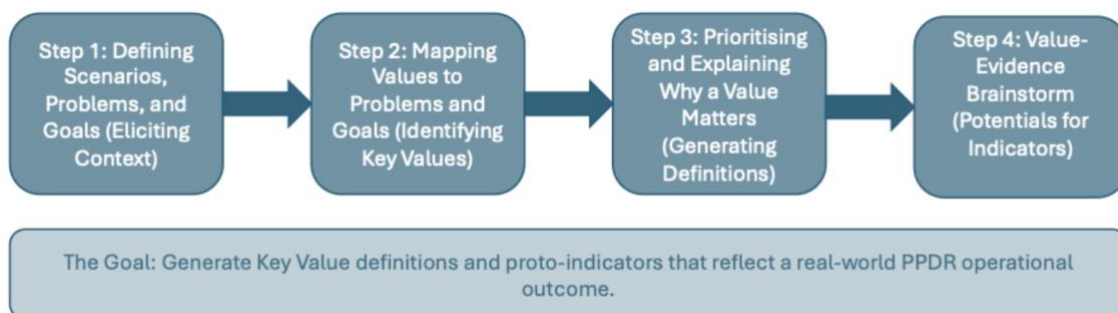


FIGURE 8 Flow of steps in the stakeholder workshop

Define the Scenarios: They were then asked to select a specific problem or scenario that is relevant to their work. This could be a response to a specific incident that they were involved with, a larger response challenge they know must be faced, etc. For example, one group chose a large-scale blackout while another chose a police chase at a border.

- 1. Map Goals/Problem with Values** Participants were provided with small cut outs with societal values on them, names only. They were explained these were a guide and for inspiration, not a limitation. They were also provided with a series of connectivity technology that pervious workshops with the PPDR community had demonstrated as highest priority. Within that frame, they were asked: What impact for society that you want you make? It could be, for example, change for communities served by PPDR agencies, change in the ability to provide hazard and risk reduction, change in preparedness, change in approved ability to respond, or change in overarching societal resilience They were then asked to select and discuss which values they saw as relevant to this. They could be from the cards they were given or could be their own addition.

They were instructed to draw the scenario on the paper, however they wanted to. Then they were asked to map the values onto it, identifying specific leverage points, problems,

or goals where, were that value to be addressed, it would likely to improve the outcomes for them or for the communities they serve.

2. For each value they paired with a problem/goal, they were asked to prioritise and write ‘why’. They were asked to take notes on their large sheet of paper about what they saw at play and why in these situations, but also encouraged to debate and discuss:

- Why does a value matter to PPDR?
- What impact/outcome do you want to see?
- What are the most important values to drive outcome and why?
- How does this change from from your role, country, or context?
- Which are the highest priority?

3. How would they know? Then, they were asked to pick one cluster of problem/goal & values that they saw as a priority. For that one, they were asked to discuss and write on their sheet: What would you look for to know that your “why” is being considered? The recordings were they to gather debate to assess if they agreed on this, if what they’d look for changed depending on role or situation, and to generally gather how it was they were interpreting the value, the sub-objectives, and its relationship to their goals as PPDR stakeholders. If time permitted, they were asked to continue this activity in order of priority.

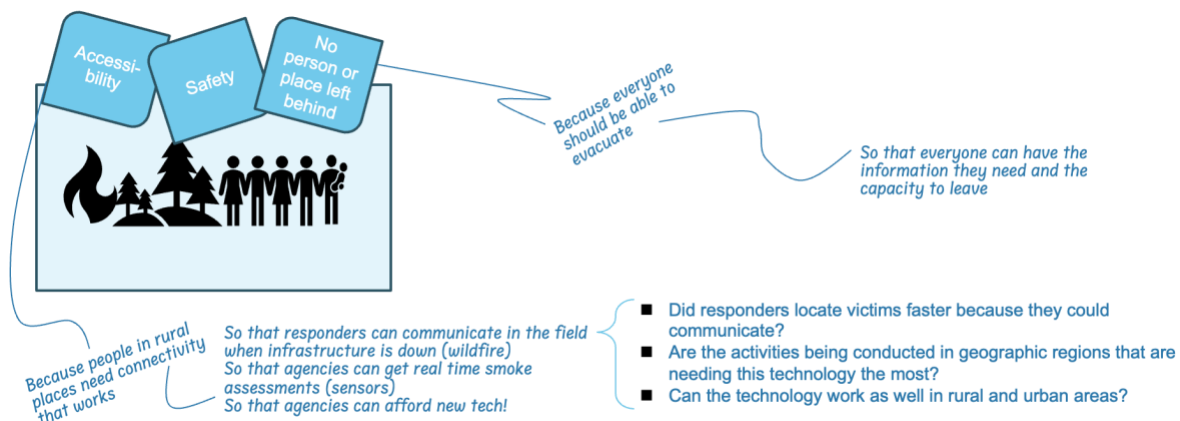


FIGURE 9 Example of workshop activity

Once the activity was complete, the small groups were asked to report back to the larger group of participants, and were able to ask each other questions.

The results were then analysed for:

- Priority values
- Value definitions and key outcomes related to them for PPDR
- Value Interrelationships
- Enablers tied to the values/outcomes
- Any elements identified for monitoring the value in practice, be it related to ICT or not.

These exercises generated discussion around why specific values matter, what outcomes they should drive, and how to measure whether values are genuinely being considered in technology development. The workshop’s long-term goal is to help the PPDR community leverage value-driven approaches like KVIs to push innovation in directions aligned with their non-market-driven needs. The outputs are both designed to support PPDR and SNS community decision-makers and ensure next-generation communication technologies prioritize what is critical for first responders and the communities they serve.

The output is a set of values defined and potential indicators that are meaningful for the PPDR community. While neither definitive nor universally applicable, these definitions and indicators represent how PPDR practitioners understand and operationalize these values in their work, as well as what they consider valid evidence of progress. It is a first step in taking abstract principles (such as European Values or the SDGs) and translating them into actionable forms.

The two-phase workshop process supported participants to move from abstract principles to concrete, meaningful indicators grounded in real-world scenarios.

Across all the groups, a core set of values consistently appears, with some emerging or receiving greater emphasis depending on the specific disaster or technological context being discussed. A set of supporting values, that were deeply interlinked with the core values also emerged. These discussions were also strongly intertwined with a set of socio-technical enablers.

The Identified Values and Enablers were:



FIGURE 10 List of values and enablers as prioritised by PPDR stakeholders

5.2. INTERCONNECTED VALUES

PPDR experts see values not in isolation, but as a deeply connected system. For example, Trust is repeatedly linked to Resilience (e.g. because resilience creates trust, and trust is needed in the systems for people to act socially in ways that support resilience) and Solidarity (e.g. how can we see that we trust each other). It is also seen as a prerequisite for information sharing and cooperation necessary for successful disaster responses. Similarly, Education is also defined as key to trust and aiding resilience. Safety was directly connected to Quality of life. From their perspective, working on one of these and not the others would be incomplete and ineffective.

There was a strong awareness amongst the PPDR that just adding technology does not automatically achieve the values; the human element (e.g., willingness to share, actual communication effectiveness) is crucial.

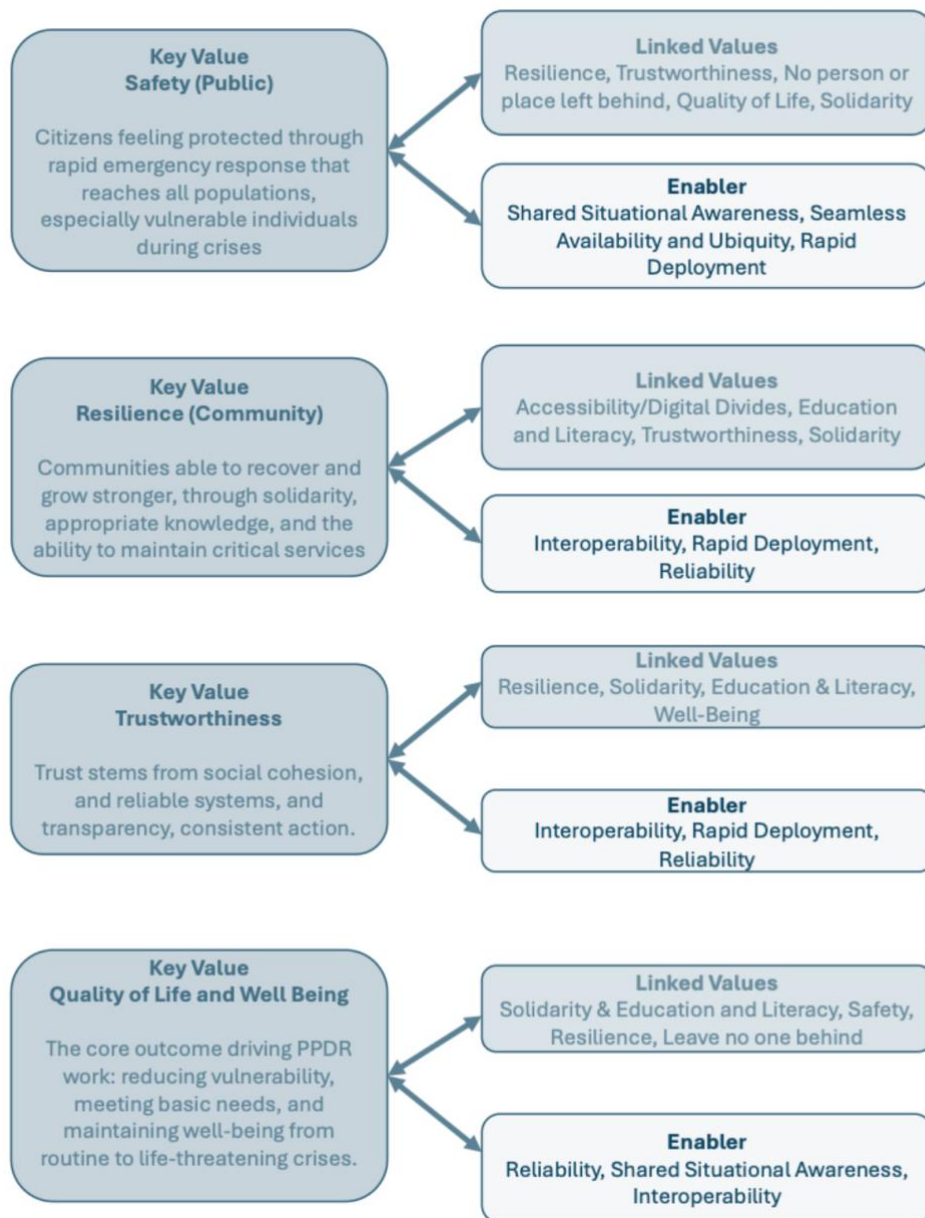


FIGURE 11 Interconnected values as defined by stakeholders

In essence, the discussions deepened from a general identification of important concepts to a more sophisticated understanding of *how* these values function, *why* they are critical in specific disaster and technological contexts, and *how* their presence or absence can be observed in real-world outcomes. Definitions became more nuanced based on the scenarios discussed, which in turn supported the identification of appropriate and relevant evidence (e.g. proto-indicators). For example, in a severe blackout, quality of life shifts from general well-being to a more basic concern for keeping people alive, or in an Earthquake accessibility shifts from generally reaching areas without connectivity to enabling responders to access remote areas, people, especially when normal networks are down, while in a wildfire, accessibility focuses on enabling responders to access remote areas. Similarly, the sources of *trust* shift depending on the scenario, where in a pandemic, trust in the state and responders as a good neighbour is key but in wildfires, trust in reliability of data became the focus.

5.3. PPDR PERSPECTIVE ON KEY VALUE DEFINITIONS AND PROTO-INDICATORS

5.3.1. PPDR Core Values

Safety: Defined also as a primary value and framed within public safety, this is intrinsically linked to quality of life and involves improving emergency response capabilities and the feeling of protection for both citizens and first responders. Inefficient response due to poor communication leads to slower response times, increased damages, and a direct threat to the quality of life and safety of citizens.

Sub-objective, Citizen Safety: Related to the tangible results citizens feel in their daily lives. It is fundamentally about protecting vulnerable individuals and ensuring no person is left behind, especially those dependent on essential services during crises. It encompasses both personal and community safety, while maintaining social trust to prevent communities from breaking down into fear.

Potential KVIs:

- Citizens have feeling of being protected
- First responders to anticipate and react faster
- First responders achieve shorter response time
- Ability to provide improved level of assistance
- Decreased response times
- Improved emergency response capabilities
- Mitigation of predicted damages
- Able to locate victims faster
- Able to access remote areas faster
- All vulnerable populations are taken care of in exercise or event
- Responders have access to necessary data for interventions
- Citizens knowing that help will arrive within a reasonable timeframe

Sub-objective, First Responder Safety: First responder safety is related to their own safety so that they can do their jobs. It depends on maintaining continuous access to reliable information and communication throughout missions, enabling them to focus on their core tasks. Responder safety means having the technological infrastructure and mental space to avoid hazardous situations while making difficult decisions about resource allocation and risk mitigation.

Potential KVIs:

- Responders focusing on their core tasks rather than managing technical issues
- Responder has improved awareness of hazards and vulnerabilities around them
- Reduced emergency response times
- Increased operational efficiency
- Timeliness, e.g. times that key decisions or events take in the exercise
- Effectiveness, e.g. compliance with procedures and results of activities performed
- Efficiency, e.g. number of personnel needed to complete a task, number of times communication was repeated
- Learning, e.g. are insights able to be gained that support governance or future PPDR activities

Resilience: Resilience is the capacity of systems, communities, and individuals to absorb shocks and recover quickly while minimizing disruption depth, emerging stronger rather than more vulnerable after crises. It encompasses three interdependent dimensions: technical resilience through interoperable, redundant systems that maintain critical functions during failures; mental resilience built on education that enables people to resist misinformation and

act decisively without panic; and social resilience rooted in trust, solidarity, and self-organization that prevents societal breakdown. It requires the confidence to take risks knowing that backup systems and mutual support networks will catch you if you fall. It is both a reactive capacity and a long-term strategic investment in mitigation and preparedness.

Sub-objective: System Resilience. System failures in communication networks directly impact interoperability among agencies and the ability to establish shared situational awareness, leading to slower response times and reduced effectiveness in mitigating damages. Keeping the public safety network running is seen as a top action to ensure interoperability in a blackout scenario.

Potential KVs:

- Dependability of a system towards goals
- Increased services availability and resilience in emergency contexts
 - Decreased communication outages
 - Level of redundancy
 - The presence of alternative solutions or alternative approach for unexpected events (e.g., a safety net for failing infrastructure)
- Access to and sharing of information (“resilience is to know what happens, because we need information”).
- Reduction in the depth of impact and quickness of recovery
- Public safety networks up and running, regardless of situation
- How quickly the system recovers
- How deep a disruption goes into a system.

Sub-objective: Community Resilience. Community resilience is about social cohesion and mental preparedness, maintaining trust, solidarity, and mutual aid networks that prevent panic during crises. Resilience means communities emerge stronger rather than weaker from shocks. It relies on accessible information flow that empowers everyone to act appropriately, supported by local backup and aid systems that maintain critical services when infrastructure fails.

Potential KVs:

- Measuring whether technology can work in both urban and rural areas
- Switching from one connectivity source to another, the change should be seamless
- Public safety network keeps running when the power network goes down
- Activities involve the public, fostering in them a sense of solidarity
- Existence of systems that support self-organization and mutual aid within the community

Trustworthiness and Trust: Trust enables cooperation, information sharing, and social cohesion. Without it, agencies won’t share data, citizens won’t heed warnings, and safety efforts collapse. It must be actively built through consistent, transparent action over time, requiring governments to demonstrate competence and care before earning public confidence, particularly by providing services and explaining why changes matter. At the community level, trust begins with neighbours and family, preventing panic and looting during crises while enabling acceptance of surveillance technologies when privacy is protected and safety benefits are tangible. Trust remains the easiest value to break down, vulnerable to misinformation, inconsistency, and broken promises, and leads to non-sharing of vital information and hindered cooperation.

Potential KVs:

- Building and Maintaining trust: Through transparency, consistent communication, and a focus on community well-being

- Consistent communication and transparency from authorities, industry, etc.
- Common goals and open dialogue/Openness and involvement
- Responders feeling encouraged to share their information.
- Standardization of services (not formal, but the idea that “McDonald’s Big Mac should taste like a Big Mac no matter where you go”).
- Able to fulfil basic needs of public during a crisis.
- Absence of complaints about critical services or technology.

Quality of Life and Well-being: This was explicitly identified as one of the major problems that PPDR must address and typically considered the top value to achieve as it is a core outcome for citizens. They described it as one of the main reasons for their work. The value encompasses elements like feeling safe and avoiding panic during crises. The aim is preserving quality of life by resilience and increased safety. While consistently mentioned, its priority can shift based on the severity of the disaster (e.g., in a blackout, keeping people alive might supersede improved well-being).

Potential KVs:

- Decrease in vulnerability
- Decrease in likelihood of panic during crisis
- Basic human needs are met
- Social and operational (responder) system stability is maintained
- Individuals feel safe, especially during severe disruptions
- Equitable access to services
- But when it comes to actual responses, this is simply the ability to keep people alive
- Improvements in urban mobility, air quality, or water quality

5.3.2. PPDR Supporting Values

Education and Literacy: Education is foundational for building resilience, community trust and social cohesion. Literacy and education are critical for closing divides and ensuring inclusivity, reaching vulnerable populations who might otherwise be left behind. Education empowers citizens with the competence to engage new technologies, make informed decisions during crises, and actively participate in preparedness processes.

Potential KVs:

- Public’s willingness to follow official guidance
- Increased competence with technology
- Citizens know how to respond to maintain their own safety
- Ability to assess information
- Systems that are user-friendly
- Ongoing literacy training over time.

Solidarity: Solidarity is the social glue that enables well-being, resilience, and mutual aid. It is demonstrated when communities spontaneously self-organize to support vulnerable neighbours, people have a sense of belonging and purpose, and it prevents panic and social breakdown during crises. Solidarity extends beyond local communities to borderless cooperation between states, allowing countries to leverage each other’s capabilities and provide fresh responders to prevent burnout during prolonged disasters.

Potential KVs

- Existence of mechanisms used by communities to organize help and resources
- Existence of trust between people.
- Ability to be proactive in activities/helping others

- The ability of countries to leverage the digital capabilities of other nations in crisis situations

Accessibility / Closing Digital Divides: Equitable ICT access is essential for resilience and leaving no person or place behind. High costs and perceived low return on investment in rural areas impede universal deployment of secure systems, creating digital divides that expose vulnerable regions to greater risks. Limited technological capacity creates safety imbalances where PPDR cannot access information, communicate effectively, or share updates with the public. Last-mile connectivity gaps and obsolete critical communication systems leave rural responders disconnected during missions, creating significant operational vulnerabilities.

Potential KVs

- Engaging Public Perceptions: e.g. that PPDR have the same technology as consumers do
- This disparity leads to unequal safety and service provision across different areas
- Connectivity in rural places that allows people to know what's going on/Technology working in both urban and rural areas. Absence of white spots (areas without technology capability)

No Person and No Place Left Behind: This underpins equitable access to safety, communication, and assistance, especially for vulnerable individuals, those with less technology, those in remote geographical areas or suffering from digital divides. It is tied to ensuring everyone can evacuate, be safe, or get the necessary aid. It asks for improved accessibility through resilient technology and continuous monitoring so the most vulnerable can be located and assisted, while preventing safety imbalances where only urban centres or wealthy regions receive secure systems. Enabled by borderless networks, agencies can leverage neighbouring countries' capabilities when needed.

Potential KVs

- Public safety services being able to reach and benefit more people
- Easier communication between agents
- More people benefiting from public infrastructure
- The public being able to access public services in all areas

Better Use of Limited Resources: Better use of limited resources and affordability means efficient management that reduces waste and maximizes output from constrained capital, materials, and personnel. It must ensure equitable allocation that makes public infrastructure accessible universally, preventing resource concentration. This ensures departments accomplish more with less through effective resource stewardship.

Sub-objective, Affordability: It requires viewing costs strategically: while interoperability demands high upfront investment, it enables competitive, leverageable systems long-term that improve decision-making, lower response times, and mitigate damages more efficiently. The political challenge is making funding available by creating awareness of why modernization is necessary, convincing stakeholders that investments deliver value, especially when crises stretch resources.

Potential KVs

- Departments do not need more resources to get job done well
- More competitive and affordable systems in the long term, potentially enabled by interoperability
- The ability to learn from/engage experts not at the scene of a disaster
- Political bodies address the affordability challenge

Sub-objective, Balancing Needs and Resources: The tension between the aspiration of no person and no place left behind and the reality of limited resources requires difficult decisions and clear operational focus during a crisis. This involves reducing waste and allocating resources more effectively to enable responders to focus on missions rather than other, e.g. technical, problems, achieving lower response times and greater impact. This efficient use of resources also contributes to affordability, as it lessens the need for additional resources

Potential KVs

- Responders are observed to focus on their main task and spend more time on the mission than fixing technical issues
- Absence of technical complaints
- Lack of the risk of an unbalance in safety, where areas remain vulnerable due to a lack of investment
- Technology works in both urban and rural areas
- Resources are made more accessible to more people
- Activities are conducted in the geographic region that needs the technology the most

Environmental Sustainability, Responsible Consumption & Production: This is not necessarily a primary focus of PPDR, as they want tools that will get their jobs done. But they acknowledge climate change's role in escalating disaster risks, such as blackouts threatening nuclear facilities or chemical factories, positioning environmental stewardship and resource efficiency as essential feedback loops that support core public safety objectives rather than competing priorities. Thus, these activities, should focus on minimizing the overall impact of PPDR operations and crises through effective resource management, monitoring environmental conditions, and improving air and water quality that directly enhance quality of life. Responsible consumption demands reducing natural resource usage, eliminating waste, and engaging efficient practices.

Potential KVs

- Energy Efficiency, in particular battery life, working in blackouts or difficult energy situations.
- Reduced usage of the natural resources
- Improved air quality and water quality
- The ability to manage critical resources like water (especially in a crisis)
- Improved ability to use technology to gain accurate environmental information

5.3.3. PPDR Socio-Technical Enablers

Interoperability: Interoperability is seen as a prerequisite for shared situational awareness. Without it, different systems and agencies cannot effectively work together or exchange information.

Potential KVs

- Improved response times and emergency response capabilities
- PPDR services working more efficiently
- PPDR able to leverage resources from other agencies and regions
- Technology able to seamlessly work across different systems and networks

Shared Situational Awareness: Vital from a PPDR point of view. This can enable better understanding of the situation and decision making, leading to decreased response times, mitigating damages, and allowing PPDR to work more efficiently towards quality of life and safety.

Potential KVs

- First responders having a complete picture of situation for educated decision making
- Effective real-time information exchange

Seamless Availability and Ubiquity: Refers to continuous and widespread availability of technology and services, ensuring users and responders maintain connectivity throughout an entire mission, even in remote areas. Also connected to this is keeping the public safety network running, such that it supports interoperability and public safety. This is also tied to the concept of borderless networks.

Potential KVIs

- Responders maintain the communication during the entire mission
- Seamless transitions between different connectivity sources without diverting user focus from their mission
- Multiplicity and redundancy in systems
- Connectivity being available everywhere that responders are

Rapid Deployment: Supports more efficient and effective planning, coordination, and repair efforts during a crisis. Without proper coordination and shared information, resources cannot be deployed optimally, leading to waste and duplication of effort.

Potential KVIs:

- Shorter response times
- Shorten time needed to grant access to a service
- Efficient and effective planning
- Responders spend more time on the mission

Reliability: Reliability is defined as the successful integration of system resilience, operational stability, and public trustworthiness to ensure that critical services and infrastructure perform consistently and predictably, especially during a crisis.

Potential KVIs

- presence of backup power systems or other technological safety nets for failing infrastructure
- interoperability to prevent reliance on a single provider/system
- consistent service quality and predictability
- willingness to share information
- seamless “last mile” connectivity

5.4. THE PATH FORWARD: BUILD A LIVING RESOURCE

This case study serves as both a living resource for 6G and PPDR communities and a model for how similar workshops can be conducted for other verticals. By building a comprehensive repertoire of such value-driven insights, 6G innovation can be better aligned with the real-world needs of the communities it is meant to serve. This activity should be one of many, even within the PPDR community. One workshop is a starting point, a proof of concept, but not the final say.

But it is already visible from this how such mapping can help address some of the challenges around mapping value to technology. The enablers listed here are socio-technical; the 6G community often speak of much more technically focused elements when speaking of enablers. But from these socio-technical connectors it becomes possible to start to see which technological elements can be tied more concretely to potential value outcomes, which are worth exploring to see if they can support such outcomes, and, most importantly, be a starting point for guiding lower TRL projects, that are separated from their future stakeholders and use cases in knowing which technologies can bring benefit and thus are worth developing further.

Another element this case study reveals is the need to consider social enablers. This is potentially a feature unique to social sustainability, but are also key elements within a system to ensure that a technology feature can lead to that value. They offered, in other words, part of a systems view that really helps map value to key nodes of activity. For example in the PPDR case, proto-KVIs suggested by the workshop participants under 'managing resources' included elements that required policy that supports improved funding (Lack of the risk of an unbalance in safety, where areas remain vulnerable due to a lack of investment), organisational changes that make it possible for smaller rural areas to have the staff and time to engage in research and innovation activities (Activities are conducted in the geographic region that needs the technology the most), and improving organisational operational efficiency and streamlining existing workflows (Departments do not need more resources to get job done well). These can be support by a range of social enablers: policy recommendations, increased tailored training opportunities, co-creation activities to understand workflow a technology might enter into, improved digital literacy benchmarks among response agencies, among many others.

Taking it outside of 6G, bicycles are known to support reduced greenhouse emissions and improving people's health and wellbeing. But giving everyone bicycles doesn't automatically create this impact. If the roads are unsafe, bicycles decrease health and wellbeing. If a family needs to commute together (e.g., with young children or an elderly parent), bicycles require further modifications to provide the benefits. If the environment is hilly, a certain level of fitness is required. The bicycle as a technology requires social enablers like pushes in road safety standards, infrastructure modifications, government support in order to have a chance at producing that outcome. If the social system is going a different direction than technology, all the investment in the technology will not result in the desired impact.

A key recommendation would be to conduct similar workshops for all verticals, building up a repertoire of such insights which can become a living resource for future projects, both ensuring work matches vertical needs but also support value-based work that matches community priorities, improving likelihood of positive impact reducing negative impact, and increasing acceptance. This ensures next-generation technologies align with community priorities and have a positive real-world impact.

6. KVIs FOR SUSTAINABILITY

6.1. DEFINING THE SHIFT TO SUSTAINABILITY

Research and Innovation projects aiming for sustainability must look beyond immediate efficiencies to address enduring, systemic change. While KVIs provide the necessary snapshot of value creation, asking “How are we doing now?” and focusing on immediate benefits, the strategic imperative of 6G demands an evolution in our thinking: a shift toward Key Sustainability Indicators (KSIs). This evolution moves beyond assessing immediate value to evaluating whether technological innovation is contributing to a truly sustainable future.

This framework proposes a shift in impact measurement from capturing value in the moment (KVIs) to a dynamic assessment of long-term sustainability (KSIs). KSIs embed time, interdependence, and systemic alignment, adding a forward-looking layer that asks: “Are we on the right path for the long run?” Short-term indicators alone cannot reveal whether immediate wins are building the foundations needed for enduring impact, or whether the solutions developed will enable flourishing within the societal, environmental, and economic systems where they must operate. The framework aims to support projects in selecting and configuring KVIs based on specific features that strengthen their connection to sustainability.

KSIs are not a new type of indicator; they are KVIs configured to assess sustainability. They extend the impact snapshot that KVIs provide by adding temporal and systemic dimensions, tracking whether the values we aim to create persist, diffuse, and remain equitable over time.

A project knows a KVI has translated to a KSI when the focus of measurement shifts from a proximal outcome to a systemic enabler of durability. While a KVI tracks the immediate change experienced by a stakeholder (e.g., a pilot user gaining access to a service), it becomes a KSI when it incorporates a temporal and systemic dimension that assesses if that value will persist and remain equitable over time. This transition is triggered when an indicator moves beyond a single pillar (e.g., social inclusion) to map interdependencies and trade-offs across the economic and environmental pillars. For example, a KVI measuring “diversity of pilot operators” becomes a KSI when it begins to track the “presence of sustainable business models” or “hardware compatibility with legacy systems,” as these metrics provide the early proof of directionality required to show that an immediate benefit will diffuse into a lasting societal shift.

Before moving forwards, it is important to note that while distinguishing between technical KPIs, UX metrics, KVIs, and KSIs provides a useful foundation, a critical gap remains: this framework still lacks clear methods for connecting these layers. Projects must validate the causal links between technical performance (e.g., latency, throughput) and societal outcomes (e.g., trust, wellbeing). Without a validated protocol that maps how specific technical thresholds contribute to Key Values, the framework risks disconnecting system architecture from social impact. Future work should therefore focus on defining the mechanisms that allow projects, and their stakeholders, to verify that 6G technology choices measurably advance social values. For example, in the previous chapters, trust is defined as a stakeholder’s **willingness to be vulnerable** based on the confidence that a system will act as intended. In high-stakes environments like Public Protection and Disaster Relief (PPDR), **system reliability and predictability** are the technical foundations of this trust. Methods are needed to a) rigorously identify these links between technical foundations and value and b) validate them for the specific context and more generally for 6G, that build upon participatory methods but go beyond them.

6.2. THE FIVE CORE PRINCIPLES OF A SUSTAINABILITY-ORIENTED FRAMEWORK

To guide this strategic shift, a sustainability-oriented framework for indicators must be built upon five core principles. These principles ensure that assessments are comprehensive, forward-looking, and grounded in the systemic realities of societal, environmental, and economic systems.

- **Assess holistically across pillars:** Assess impact simultaneously across societal, environmental, and economic dimensions of sustainability. Integrate complementary methods, disciplines, perspectives, especially those that mix top-down and bottom-up, to capture sustainability's complexity [74] [7] [1] [13] [75] [76] [77] [78] [79] [80].
- **Map interdependencies and trade-offs:** Evaluate how actions in one area create consequences in others, and how they raise challenges around trade-offs [81] [82] [83] [84] [85].
- **Orient towards the future:** Track both immediate results and signals that solutions will persist, diffuse, and remain effective over time. Look for signals of adaptive capacity and resilience [86] [87].
- **Ground decisions in stakeholder engagement and a theoretical framework:** Co-define what sustainability means by engaging diverse stakeholders, especially those most affected in the context being explored. Ground the decisions (about values and indicators) in a theoretical framework that clarifies the purpose of the assessment [88] [89].
- **Identify the contextual boundaries within which solutions must operate:** be transparent about both the ecological limits and equitable distributions that ensure legitimacy and justice across who benefits and who bears costs. Clearly articulate progress towards what and for who, ensuring the means do not become the end of the analysis, and helping to identify realistic leverage points [80] [90].

Overall, addressing KVs for sustainability (KSIs) requires adopting a holistic, multi-level framework that aligns strategies across individual, organizational, and policy levels. This includes addressing immediate downstream needs (e.g., providing devices or training) while simultaneously tackling upstream structural barriers (e.g., funding broadband expansion or reforming policy) to achieve lasting change.

These principles provide the strategic foundation for engaging KVs to support sustainability assessment. This requires actions on two fronts:

- Projects should be responsible for providing early proof of directionality (securing the KSI signals), often grounded in a theoretical framework.
- Institutional/funding bodies should be responsible for long-term follow-up and scaling, often grounded in governance and strategic policy.

6.3. OPERATIONALISING THE SHIFT FROM VALUE TO SUSTAINABILITY

This section offers a proposal for how to operationalise the KSI principles into practice, by working through a scenario based on equitable access to/from 6G and presenting examples of how each of the principles can be enacted in indicator planning. The goal is to set a high bar for sustainability proof without making the process so demanding that it becomes impossible to meet. It also tries to translate the principles into something actionable.

The following steps outline how project teams can begin generating early evidence of sustainability directionality:

1. **Frame your sustainability ambition and boundaries:** What change are you pursuing and over what timeframe? What are the non-negotiable success conditions?

2. **Scope relevant sustainability elements:** Map which values and related socio-technical enablers (equity and justice, ecological limits and regeneration, circularity, decent work and inclusion, etc.) your work directly or indirectly affects.
3. **Assess interdependencies and trade-offs:** Plan how you will interpret indicators in relation to each other. How do improvements in one area create consequences in others?
4. **Design a future-oriented indicator set:** Select indicators that cover multiple sustainability dimensions and multiple time horizons (immediate outcomes + signals of durability, diffusion, and long-term viability).
5. **Integrate complementary assessment methods:** Integrate diverse approaches (e.g., quantitative metrics, qualitative assessment, stakeholder engagement) to capture sustainability's complexity.
6. **Establish governance for ongoing learning:** Create mechanisms for regular review: who assesses progress, when, and how do findings influence project decisions and direction?

6.3.1. Frame Your Sustainability Ambition and Boundaries

Before selecting indicators, clarify what sustainability means in your project's specific context: what type of change you aim to influence, over what timeframe, and why these elements are priorities. This initial framing establishes both a compass for interpreting future impact and a foundation ensuring indicator selection is driven by a clear, realistic, and legitimate vision of change. To do this, consider 3 things:

- **Type of sustainability change:** Articulate whether your project is optimizing within current systems (e.g., improving efficiency), reforming governance (e.g., changing how decisions are made), or contributing to a transformation (e.g., enabling fundamentally different relationships between technology, society, and the environment).

Example Step 1

Type of sustainability change: A project developing energy-efficient network protocols is primarily optimizing within current sustainability constraints (reducing energy per data unit). However, it could contribute to sustainability transformation if the protocols enable fundamentally different network architectures, such as low-power designs that make connectivity viable in resource-constrained settings, expanding equitable access.

Sustainability timeframe and pathway: Immediate outcomes might include X% energy reduction per gigabyte transmitted (measurable within 3 years). Longer-term sustainability changes could include deployment in underserved regions where lower energy requirements reduce infrastructure costs and enable connectivity for currently excluded communities, adoption by diverse types of network operators (not just major telecom companies), or rebound effect mitigation that ensures efficiency gains lead to reduced total consumption rather than increased use. These do not have to be outcomes you can achieve within the project, but they define where you are trying to contribute.

Grounding Priorities for Legitimacy: Engaging with network operators, communities facing digital exclusion, and environmental groups might reveal different priorities. If community stakeholders emphasize that access barriers are more urgent than incremental efficiency gains in already-connected areas, this suggests you need indicators tracking deployment feasibility and actual access in underserved regions, not just peak performance metrics. If environmental stakeholders demonstrate that rebound effects are the critical concern, this suggests you need indicators measuring total system energy consumption and usage patterns, not just per-unit efficiency. These stakeholder insights should directly shape which indicators you select and prioritize.

- **Sustainability timeframe and pathway:** Define the immediate outputs you expect within the project period and the longer-term changes your work might enable through specific mechanisms.
- **Grounding Priorities for Legitimacy:** Discuss your framing with key stakeholders, especially those most affected by the sustainability challenges you address, to ensure your definition of “better” or “success” aligns with their priorities. Ground these insights in a theoretical framework that offers a systemic view.

Why not just use SDGs or EU 2050 targets directly? While high-level frameworks like the Sustainable Development Goals (SDGs) provide essential guidance, they operate at a national and global scale. Simply mapping your work to “SDG Goal X” fails to explain the specific mechanism linking a technical improvement to a sustainability outcome. You must articulate how your technical achievement is supposed to create sustainability change in order to select the right evidence and indicators.

6.3.2. Scope Relevant Sustainability Elements

It is next important to connect a project’s ambition to concrete aspects of sustainability across the societal, environmental, and economic pillars. This will involve mapping which sustainability elements the work directly or indirectly affects each dimension. This helps determine which impacts are central and which are peripheral, guiding focused indicator development. For each relevant element, clarify the key questions your indicators need to help answer. The framework uses the Triple Bottom Line as a foundation, but requires identifying specific elements within each dimension and articulating what you need to assess.

A note: This activity is grounded in systems thinking, which can be complex. However, such an approach is valuable to frame and understand the sustainability challenge at hand. Once established, it is possible to argue for which reductionist approaches, focusing on simpler and narrow issues, are more appropriate to act on [91]. Only then can the more narrow actions be justified and legitimised. While balanced assessment across dimensions is ideal, focus on elements your project meaningfully affects. It is better to deeply assess 2-3 relevant elements, with a strong grounding as to why those two are priority (rather than convenient) than superficially check boxes across all three dimensions.

How this could be done:

- **Impact pathway mapping:** Work backward from your intended change to the current state to identify which elements are preconditions for the outcomes. For example, energy efficiency only improves access if affordability is the primary barrier.
- **Documenting reasoning:** Create a sustainability scope document explaining why you selected certain elements and excluded others, ensuring transparency.

- **Checking for systemic connections:** Use frameworks like the SDGs as prompts to identify interdependencies. If you address one goal, which others does it connect to? Ground these connections in existing research.

Example Step 2 (not a full scoping document, preliminary entry points only)

TABLE 5 Example of mapping key sustainability elements to equitable access to/from 6G

Sustainability Pillar	Key Elements to Map (Examples)	Questions (Examples)
Societal	e.g. Equity and Justice, Access and Inclusion, Wellbeing, Capacity Building, Decent Work.	Who benefits and who bears costs? Does the work reduce or reinforce inequalities? Are marginalized groups included? Does it build local capacity or create dependencies?
Environmental	e.g. Ecological Limits and Regeneration, Circularity, Resource (including energy) Efficiency, Life Cycle Impacts, Biodiversity	Are there rebound effects that increase total consumption? Does the code require frequent hardware upgrades (driving e-waste)? Can it run on existing/older hardware (extending device lifespans)? Does it enable or hinder device repair and reuse?
Economic	e.g., Economic Viability, Market Diffusion, Decent Livelihoods.	Is the solution economically sustainable beyond project funding? Does it create quality economic opportunities? Can it diffuse to those who need it most? Does it build or extract value?

Preconditions: marginalised groups are included in the design decisions, network demands are addressed so that rural areas have equal service as urban areas, e-waste is reduced so people can keep their devices, device compatibility with new services, reliable power structure, affordable data plans, digital literacy and cultural relevance, trust in the technology and service providers.

6.3.3. Assess Interdependencies and Trade-Offs

Sustainability is systemic, and progress in one area often comes with consequences (positive and negative) elsewhere. Sustainability cannot be understood by looking at dimensions in isolation. Trade-offs between different sustainability elements, or between a sustainability element and a performance or market driver, are always difficult decisions. Assessing interdependencies and trade-offs helps reveal where progress in one area may create challenges or opportunities in another, and where leverage points exist for systemic benefits or risk harms. It also helps clarify priority and success models. Every action has impacts and consequences elsewhere in the system that need to be acknowledged to really propel a benefit forwards.

Example Step 3

TABLE 6 Example of mapping interdependencies for equitable access to 6G

Value	Connection to Inclusivity and 6G
Digital Literacy & Skills	Exclusion deepens if skills do not match the tech, and communities either cannot use what is provided or can't maintain it
Energy Consumption & Efficiency	Expanding access (societal) must not lead to unmanageable energy demand or emissions increases
Resource Conservation	Low-income users often rely on older, less-efficient devices, creating a cycle of digital and material waste exclusion.
Affordability & Cost	Inclusivity is impossible if the technology is too expensive for marginalized groups.
Economic Growth	Inclusivity requires that the economic benefits are accessible to SMEs and rural areas.

Example Trade-Offs relevant to these interconnections:

- **Energy efficiency vs. hardware requirements:** If achieving efficiency gains requires newer hardware with specialized chips, you may reduce per-unit energy but increase e-waste and deployment costs, undermining both ecological circularity and economic accessibility goals. Monitor: Do efficiency improvements correlate with hardware upgrade requirements?
- **Deployment in underserved areas vs. total energy use:** If protocols successfully enable connectivity in new regions, total system energy consumption will increase even if per-unit efficiency improves. This could be acceptable if it advances equity goals, but monitor: Is the energy increase proportional to new access gained, or are rebound effects occurring in already connected areas?

To move beyond immediate social value, assess impacts across all dimensions of sustainability; recognise their interconnections and select based on this. It is important to focus on both the positive (handprint) and negative (footprint) impacts as part of this.

How this could be done:

- **Work through pre-existing literature:** Research how the areas you aim to improve relate to other sustainability dimensions to understand the holistic conditions needed for impact.
- **Create a Trade-Off Matrix:** Early in the project, document the potential positive and negative impacts for every major intended gain. For example, an energy-saving innovation may have consequences for social equity or create new capacity-building risks. Pre-agree on the acceptable bounds for any negative trade-offs.

6.3.4. Design a Future-Oriented Indicator Set

Indicators turn intentions into evidence. Designing a multi-dimensional indicator set ensures you are tracking immediate outcomes and early signals of long-term sustainability capturing not just efficiency gains but also the durability and systemic effects of your work.

With interdependencies understood, now select indicators that reflect sustainability across multiple dimensions and time horizons. This ensures your measurement system captures both

immediate outcomes and signals of long-term viability. Sustainability assessment requires a framework that considers how present needs are met without compromising the ability of future

Example Step 4

TABLE 7 Examples of KSIs

Pillar	KVs	Immediate outcomes (within project period)	Longer-term signals (measurable within project, indicative of future sustainability)
Social	Access and inclusion	KVI: Number and diversity of operators participating in pilot deployments (adoption breadth signal)	KSI: Interest and capacity assessment from community/small operators: Are they engaged in pilots and do they have pathways to adoption post-project? (proxy for future equitable diffusion) KSI: Documented barriers to access in target communities: are these being addressed or remain unchanged? (proxy for if access can lead to inclusion)
Economic	Economic viability in low-resource settings	KVI: Deployment cost per user in low-resource settings compared to conventional protocols (viability indicator)	KSI: Presence of sustainable business models: have any pilot operators identified viable economic pathways beyond project funding? (proxy for durability) KSI: Engagement from diverse operator types: are major telecoms AND community networks involved, or just one type? (proxy for market concentration vs. distribution)
Environmental	Energy efficiency and life-cycle impacts	KVI: Energy consumption per gigabyte transmitted in test deployments (technical efficiency baseline)	KSI: Hardware compatibility: can protocols run on existing infrastructure versions, or do they require upgrades? (proxy for resource conservation) KSI: Stakeholder assessment of rebound risk: do operators/users anticipate efficiency enabling increased consumption or reduced total use? (indicates circularity potential and deployment barriers)

generations to meet theirs. The key challenge is finding early evidence a project can provide that shows it actually bends the curve on a sustainability problem. While measures within a project cannot provide evidence of actual outcomes after deployment (e.g. it is not possible to measure lives saved or livelihoods improved), there can be proxy indications of future sustainability. Design a set that covers multiple time horizons and tracks both direct project outputs and indicators of macro-level change.

Start from existing, established indicators, when possible. Which indicator sets already capture elements relevant to sustainability? Which need to be extended or reconfigured to reflect durability, diffusion, or systemic alignment? Which can be translated to the 6G ecosystem?

6.3.5. Integrate Complementary Assessment Methods

No single metric can capture sustainability. Combining quantitative, qualitative, and participatory approaches provides a richer, more credible picture of progress, helping projects understand both what is changing and why it matters, which is needed to identify what to focus on.

Sustainability's complexity requires integrating different types of evidence and perspectives that reveal different dimensions of change. Combining different methods ensures that the full

picture of change is captured, e.g., what happens, how it happens, and for whom. This can draw upon, among others: quantitative metrics, qualitative assessments, participatory evaluation, systems mapping, comparative analysis, life-cycle assessments, societal readiness assessments, social return on investment, as many more.

Why multiple methods matter:

- Quantitative metrics show *what* and *how much*
- Qualitative methods reveal *why*, *how*, and *for whom*
- Participatory approaches ensure *relevance* and *legitimacy*
- Systems perspectives uncover *structural factors* that enable or constrain change

How this could be done:

- **Combine measurement approaches:** Use quantitative metrics for tracking performance and scale (energy use, costs, adoption rates), qualitative assessment for understanding context and mechanisms (stakeholder interviews, case studies), and participatory methods for co-defining success and interpreting findings with those most affected.
- **Track patterns, not just points:** Do not just measure whether a target is hit; track the rate of change and stability. Does progress plateau quickly or show sustained momentum? Can gains be maintained under changing conditions? Patterns over time reveal more about sustainability potential than single measurements.
- **Integrate perspectives systematically:** Plan how different methods inform each other. For example, if quantitative data shows deployment costs decreasing, qualitative interviews can reveal whether this makes adoption more likely or whether other barriers remain dominant.

Example Step 5

Combining methods: Track energy consumption and deployment costs quantitatively while conducting qualitative interviews with diverse operators, especially smaller, rural, or community-based providers, about real-world barriers to adoption. Use participatory workshops with underserved community stakeholders to interpret what viable deployment and accessible connectivity actually mean in their contexts. Numbers alone will not reveal whether cost reductions translate to equitable access given local economic conditions, infrastructure gaps, or capacity constraints.

Tracking patterns over time: Do not just measure whether you achieved X% energy reduction or cost savings; track whether these gains enable broader adoption across different operator types and geographies. Monitor whether smaller operators show growing interest and capability to deploy, or whether barriers persist despite technical improvements. Assess whether efficiency gains remain stable as protocols scale to diverse environments, including resource-constrained settings.

Integrating perspectives: If quantitative data shows deployment costs decreasing but qualitative feedback reveals that technical complexity, training and literacy requirements, or maintenance burdens remain prohibitive for community networks or rural operators, this integration exposes that cost reduction alone will not achieve equitable access. You may need to prioritize simplified architectures, better documentation, local capacity building, or different deployment models over further technical optimization to ensure 6G reaches underserved populations.

6.3.6. Establish Governance for Ongoing Learning

Sustainability is a continuous process of learning and adjustment. Embedding governance and review mechanisms ensures sustainability indicators guide real decisions, shaping the project's direction rather than serving only as post-hoc reporting tools. This principle becomes

actions that are not just for projects but for the support structures around them, from funding bodies to expert advisory groups.

To ensure sustainability remains central throughout the project lifecycle, governance structures must turn measurement into learning and course correction. This step embeds review, reflection, and decision-making mechanisms that keep sustainability visible and actionable, not just reported, to ensure continuous learning and accountability for the long-term KSIs.

Some examples of how this could work:

Regular sustainability review cycles: Quarterly team meetings specifically examining sustainability indicators (not just technical milestones). Review all three dimensions together to spot trade-offs early. Standing agenda item should be to ask: “What are we learning about our pathway to equitable access?”

Stakeholder advisory panel: Semi-annual meetings with representatives from community networks, digital inclusion organizations, and environmental groups identified in the stakeholder mapping activities. They review indicator data, provide context on what is changing in their domains, and advise on whether the project remains on a credible sustainability pathway or needs course correction.

Decision triggers: Pre-define what findings would prompt project changes. For example: “If hardware compatibility drops below X%, we revisit protocol design to reduce upgrade requirements,” or “If operator diversity decreases, we prioritize simplification and documentation over performance optimization.”

Documentation and transparency: Maintain a sustainability assessment log tracking:

- what is being learned,
- trade-offs encountered, and
- decisions made with indicator results.

Share this with funders and broader research community, contributing to collective learning about how R&I projects can pursue sustainability transformation, not just technical innovation.

Integration with technical governance: Ensure sustainability indicators inform technical decisions, not just exist in parallel. When technical teams propose protocol modifications, standard review includes: “How does this affect our sustainability pathway? What do our indicators suggest about this direction?”

Example Step 6

TABLE 8 Example of governance needs

Governance Mechanism	Action	Application Level
Phased Funding	Mandate that second-phase funding requires documented commitment and budget allocation by two non-profit partners for deploying the platform in low-income or rural areas.	Project Level
Institutionalized Rolling Follow-Up	A subsequent R&I project receives a small budget to survey the original platform’s users 5 years later, measuring long-term gains and <i>dependency</i> on external.	Ecosystem Level
Procurement Alignment	Future institutional procurement for 6G technology must use an Equity Check Indicator as a mandatory, weighted criterion.	Policy/National Level

6.4. AN INTERCONNECTION EXAMPLE

This section demonstrates how KSIs in the development of 6G are not isolated metrics but are deeply interconnected assessments across social, economic, and environmental dimensions. By using digital inclusivity as an exemplar, we can map how a single policy goal, such as bridging the digital divide, triggers a cascade of effects. This approach shifts the focus from siloed technical performance observations to a holistic value-web, where progress in one pillar (e.g., social sustainability) must be balanced against potential tensions in others (e.g., environmental and economic sustainability).

The Foundation of Digital Inclusivity

Digital inclusivity is no longer defined solely by physical access to a network. Theoretical frameworks, such as the Three-Level Digital Divide, emphasize that inequality persists across three intertwined levels: the first-level (physical and financial access), the second-level (skills and meaningful usage patterns), and the third-level (the ability to derive tangible socio-economic benefits) [92]. Four critical dimensions for vulnerable groups need to be considered: availability, affordability, digital literacy, and content sensitivity [93]. In 6G, this intertwines the need for universal access, strategic infrastructure investment, affordability of services and devices. Digital Inclusivity promises socio-economic benefits, such as economic growth, job opportunities, etc. But it also requires financial investment to support the growth in infrastructures and devices needed to make services accessible. This new infrastructure also could increase the environmental footprint and the potential to generate more e-waste as people upgrade their equipment and devices. In addition, without digital literacy, the capability to navigate advanced 6G interfaces, access remains hollow, failing to translate into the economic growth or social mobility promised by next-generation connectivity. A lack of digital skills acts as a barrier to innovation and security, effectively excluding populations from the societal benefits of ICT, including 6G. Instead of bridging current digital disparities, 6G and related technologies risk reproducing such patterns unless there is inclusive planning [94]. This suggests that the ability to derive tangible benefits for 6G will only widen if the underlying access, literacy, affordability, and resource gaps are not addressed before these new frontiers become mainstream.

Intertwined Features

Based on the above review, operationalising digital inclusivity with a focus on equitable access for 6G, must include indicators from the Social, Economic, and Environmental pillars. The following table illustrates how specific features are fundamentally linked.

Pillar	Feature/Indicator	Connection to Literature & Interdependency
Social	<p><i>Skills, literacy, access, availability</i></p> <p>KSI combination:</p> <ul style="list-style-type: none"> - 6G network coverage by income or geographic region - Affordability burden, predicted % of income spent on 6G services - Digital literacy for 6G applications, based on task completion success ratio - % of documented barriers to access in target communities that 	<p>Without high success ratios in literacy, users cannot reach the “Third-Level” of tangible outcomes, regardless of network speed [92].</p>

	are being addressed, per external audit	
Economic	<p>Financial access, affordability</p> <p>KSI combination:</p> <ul style="list-style-type: none"> - Cost per gigabit for different user segments - SME access to 6G-enabled services - Ratio of pilot operators identified viable economic pathways beyond project funding 	<p>Despite 5G expanding four times faster than its predecessor, infrastructure density has struggled to maintain pace with this growth. This is evidenced by inconsistent coverage and around 20% speed gaps between rural and urban areas in France, Spain, Germany, and even more in the UK, and large 5G availability gaps remain [95]. In Greece, there is a 40% gap [96].</p> <p>In addition to service barriers, affordability remains key to people getting access to mobile broadband services [76]. But this comes with fears that affordability stands in tension with return on investment for those providing the infrastructure [97].</p>
Environmental	<p>Energy, resources</p> <p>KSI combination:</p> <ul style="list-style-type: none"> - Energy consumption per bit - Predicted E-waste generation from device upgrade cycles - Carbon intensity of networks, via models - Proportion of polled energy policy experts assessing rebound risk as acceptable via Delphi methodology 	<p>Universal access requires investment in infrastructure [98].</p> <p>Expanding digital access grows our ecological footprint by requiring more infrastructure. From base stations to data centres, the entire lifecycle of this hardware (including manufacturing and operation) demands significant energy and raw materials [97] [99].</p>

TABLE 9 example of interconnected KSIs

Below is a short summary of the intertwined digital inclusivity issues, both handprint and footprint, that need to be considered. For each of the three pillars, an example social enabler indicator is provided. For equitable access, pair immediate technical indicators with assessments of how design choices address existing barriers. Coverage expansion should be paired with evidence that deployment strategies actively consider and mitigate barriers facing underserved communities. Reduced service costs should be paired with identified economic pathways demonstrating how affordability translates beyond project funding into sustainable access. Decreased energy per bit should be paired with expert assessment of rebound effect risks that could undermine efficiency gains. This approach combines indicators of present capabilities with proxies for future equitable outcomes, ensuring technical progress creates genuine conditions for access rather than theoretical possibility.

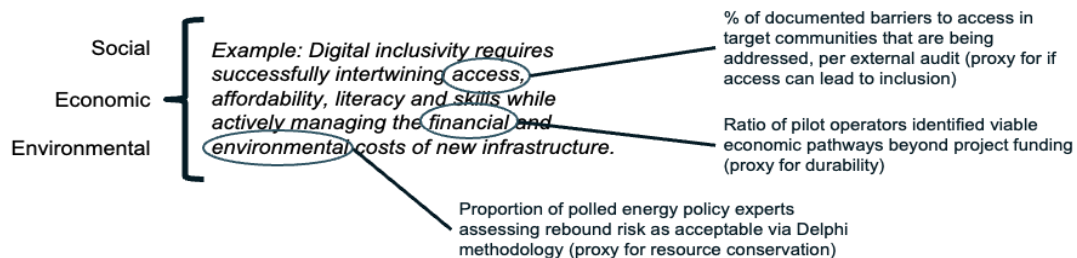


FIGURE 12 Example of interconnected KSIs working off a value foundation

7. FUTURE DIRECTIONS

Frameworks and methodologies come to life through practical application. This final section describes the strategic next steps necessary to implement the KSI framework, and KVIs more generally, across the SNS JU ecosystem, by offering specific guidance to projects, industry groups, and policymakers.

7.1. OPERATIONAL RECOMMENDATIONS

Recommendation 1: Harmonise definitions of and priorities within key values

Coherent definitions and strategic prioritization of Key Values, the objectives within and how they matter to 6G and to the world 6G will enter into are essential for cross-project learning and 6G development alignment. Harmonization would strengthen project comparability, increase KVI relevance, and position values as foundational principles for research direction rather than afterthoughts.

- **Harmonise Key Value definitions:** Develop clear, consistent definitions to ensure alignment on what is being measured and why it matters.
- **Establish a strategic KVI scoping framework:** Provide guidance to help projects define appropriately ambitious KVIs that remain manageable, relevant, and realistic given their context and maturity level.
- **Facilitate stakeholder consensus-building:** Create forums and activities that build shared understanding of societal values, sustainability, and KVI priorities across all 6G stakeholders, from industry to end-users.
- **Clarify values as selection criteria:** Articulate how values should inform project selection, call topics, and funding priorities, particularly for lower-TRL work where values drive direction rather than measure impact. This guidance should support Framework Programme 10 planning and future strategic decisions.

Recommendation 2: Strategically navigate trade-offs

Explicit frameworks for managing trade-offs between cost, performance, and sustainability enable more transparent decision-making that balances business objectives with Europe's long-term societal ambitions for 6G.

- **Develop trade-off navigation frameworks:** Create policy and strategic guidance that helps projects systematically address tensions between technological feasibility, business viability, and sustainability goals, making implicit choices explicit and accountable.

Recommendation 3: Develop a process for defining and validating proxies

Proxy indicators allow low-TRL projects to track value-related progress without requiring long-term impact studies, provided they are grounded in realistic use cases and stakeholder input.

- **Ground proxies in real contexts:** Design proxy indicators with input from stakeholders from outside industry (e.g., first responders), civil society, and affected communities to ensure credible assessments and outcomes.
- **Acknowledge context-dependent thresholds and baselines:** Recognize that acceptable performance varies significantly across use cases (e.g., emergency response vs. routine low-bandwidth applications) and adjust expectations accordingly.

Recommendation 4: Build multidisciplinary capabilities

Effective KVI development requires multidisciplinary expertise and clearer methods for using qualitative and non-technical data to assess realistic, near-term outcomes rather than user experience or imagined long-term impacts.

- Foster multidisciplinary teams: Promote collaboration between technologists, social scientists, economists, and domain experts in defining, assessing, and implementing KVIs.
- Provide guidance and training on qualitative and non-technical data use: Develop clear processes for gathering, interpreting, and integrating non-technical data into KVI assessments.
- Focus on tangible near-term outcomes: Shift emphasis from abstract long-term projections to trackable immediate changes that projects facilitate that demonstrate progress and maintain accountability to SNS stakeholders. Move away from the idea of KVIs that are only measurable after a project is over. Tracking these immediate proxies is difficult to do but supports transparency and accountability to SNS stakeholders.

Recommendation 5: Make KVIs indispensable to design decisions

Maximum impact requires treating KVIs as foundational design elements that guide use case selection, architectural choices, and project priorities from inception.

- **Embed KVIs at project conception:** Integrate KVIs into early strategy and scoping processes rather than treating them as assessment add-ons, ensuring societal and sustainability goals meaningfully shape technical decisions, even at the proposal stage. This means using KVIs in proposals not just as statements of what long term impact is expected but as foundational to how and why the project focuses on what it does.
- **Clarify KVI-KPI relationships:** Develop robust methods for validating KVIs and mapping their connections to technical KPIs, without reducing them to KPIs, reinforcing the role of sustainability and real-world contexts in steering innovation.

7.2. SUPPORT STRUCTURES RECOMMENDATIONS

Recommendation 6: Build shared accountability for long-term impact

Individual projects cannot track societal shifts that emerge years after completion. Portfolio-level governance mechanisms must ensure sustained accountability for values beyond project lifecycles.

- Establish portfolio-level transparency, accountability, and tracking mechanisms: Create structures that monitor the relationships between values/sustainability and indicators, as well as the long-term outcomes across projects to enable course corrections based on KVI findings, not just documentation of results.
- Develop mechanisms for decision-making: KVIs are not just proposals or descriptors. Support projects in better identifying the opportunities for change and how to manage negative findings.
- Pilot and iterate systematically: Pilot KVIs to identify which proxies correlate with social outcomes and refine indicators and related recommendations and standards accordingly.
- Require transparent public reporting: Mandate clear disclosure of claimed values, measurement methods, and thresholds so regulators, users, and civil society can hold projects accountable.
- Define consequences for unmet KVIs: Clarify what is at stake for research trajectories and funding decisions when KVIs fail to guide the project's evolution, making accountability meaningful rather than symbolic.
- Create shared knowledge infrastructure: Establish collaborative learning spaces and co-owned documentation so KVI expertise and lessons learned remain accessible beyond individual projects or individuals.

Recommendation 7: Provide adequate resources and incentives

Meaningful KVI engagement requires dedicated capacity, multidisciplinary expertise, and structural support beyond current project expectations. They also require people to work together and produce results that stand outside their immediate project results.

- Enable experimentation and adaptation: While maintaining KVIs in proposals, allow flexibility for projects to adopt new indicators, explore different methods, and build on emerging lessons without penalty.
- Incentivise cross-project and disciplinary collaboration: Structure funding and deliverable requirements to reward knowledge sharing and collaborative KVI development. At the project level, teams can self-organise informal peer-review session with other projects, stakeholders, and external experts to share KVI methodologies, findings, and lessons learned.
- Fund multidisciplinary capacity: Specify required skills (ethicists, social scientists, design researchers) in calls and provide resources to embed these roles within technical teams rather than expecting technologists to cover all domains. Within current constraints, projects could potentially reallocate time to include these experts in early brainstorming and ongoing check points throughout.
- Optimise internal workflows to better include KVIs: Projects should integrate KVI discussions into existing monthly status reviews that track project progress and in which key decisions get made on project direction.
- Support early stakeholder engagement: Provide guidance and resources for engaging stakeholders during proposal development and throughout projects (even if the project does not have use cases), not after commitments are made.

Recommendation 8: Define strategic direction for 6G social value

Projects need top-down clarity on what success looks like for 6G's societal contribution to inform bottom-up implementation.

- Articulate 6G's societal vision: Develop a concrete picture of 6G's intended contribution to society that guides value priorities and goes beyond technical performance metrics. This is particularly important if the desire is to have a small number of indicators all projects can assess.
- Provide strategic guidance on Key Values: Clarify which values matter most and how they are interrelated, which objectives within them should be prioritized, and how these align with policy goals like SDGs, reducing current fragmentation across projects.
- Define actionable objectives: Establish value and sustainability goals so progress becomes trackable and KVIs guide path-defining decisions.
- Create coordination mechanisms: Establish regular forums for revisiting values and sustainability priorities as contexts evolve, recognizing that this work is continuous rather than one-time.
- Link KVIs to policy incentives: Map indicators to sustainability targets and procurement criteria so industry recognizes both monetary and reputational value in achieving them.

7.3. POLICY AND FUNDING RECOMMENDATIONS

Recommendation 9: Align with mandatory reporting frameworks

The framework should be revised to explicitly align with the European Sustainability Reporting Standards and Corporate Sustainability Reporting Directive, ensuring KVIs and KSIs complement, rather than compete with or add to, mandatory regulatory reporting. Without this alignment, KVIs and KSIs risk being marginalized as low-priority voluntary CSR metrics rather

than core business drivers. Since 6G industry operators are legally required to report against these standards, they will align their internal indicators accordingly. A separate framework using different terminology and metrics will likely be viewed as a redundant administrative burden and ignored.

Recommendation 10: Align policy drivers and research impact

This work informs the full trajectory from policy drivers to sustainability outcomes, connecting SNS JU-funded R&I to Europe's strategic priorities articulated in the 2024 The Draghi Report on economic competitiveness [100] and Niinistö Report on societal resilience [101]. Europe's traditional leadership in telecommunications now faces global competition from actors with different political objectives and shifting geopolitical realities demanding new priorities around preparedness and resilience.

European R&I must strive to focus not just on developing bigger, faster technology, but on why European Smart Networks and Services is better to fulfil societal and sustainability needs. It should demonstrate an approach that other regions can learn from and strengthen European competitiveness in the process.

Current SNS researchers and innovators show varied perspectives on KVs. While some recognize their value, many remain sceptical as they have to navigate uncomfortable culture changes, including budget-sharing with social scientists who have only just arrived on the scene in SNS activities of Horizon Europe.

Learning from this experience can help Framework Programme 10 to better drive R&I to more effectively foster the information exchange and cross-sector cooperation needed to bolster competitiveness, environmental health, and the resilience of our social and safety infrastructures.

- Harmonize impact assessment requirements: Standardize impact criteria across FP10 using proposal templates and evaluation processes built on Key Impact Pathways, informed by lessons from KV and KVI development in SNS JU.
- Provide systematic guidance and support: Ensure SNS JU, private sector partners, and CSAs deliver training and assistance to proposers and projects on defining and implementing KVs appropriate to their scope and goals.
- Scale approach based on project maturity: Emphasize societal impact assessment particularly for higher-TRL innovation actions while adapting expectations for fundamental research.
- Extend best practices across domains: Apply approaches proven effective in demand-led topics like Cluster 3 Civil Security uniformly across FP10 R&I activities.

Collectively pursuing these actions will build the capacity, tools, and shared understanding necessary to realise sustainable, human-centric 6G grounded in shared values and focused on meaningful, lasting, equitable impact.

CONCLUSION

The development of 6G represents a pivotal opportunity to move beyond purely technical metrics and embed societal values and sustainability into the core of the innovation lifecycle. By operationalising Key Value Indicators (KVIs) and transitioning toward Key Sustainability Indicators (KSIs), the 6G4Society project provides a roadmap for ensuring that next-generation networks contribute to a more inclusive, resilient, and human-centric digital future.

The framework establishes that for values like inclusivity, safety, and trust to be meaningful, they must be decision-relevant and co-defined through deep engagement with stakeholders, and consider social enablers as much as technical enablers, looking at the context of deployment, who is involved in decision-making, and who is listened to along the way. As demonstrated by the PPDR case study, abstract principles only become actionable when translated into the operational realities of the communities they are intended to serve.

Moving forward, the successful integration of this framework requires a significant culture change within the research and innovation community. This includes the formation of multi-disciplinary teams, bridging the gap between technologists and social scientists, the establishment of a harmonised strategic language across the SNS JU ecosystem, and the adoption of new methods and data sources. In addition, a mixture of bottom-up and top-down decisions about which values and objectives within are priorities for 6G; should the values be decided by the 6G industry community, by stakeholders, by policymakers, by verticals, or by a combination thereof. It also requires the establishment of governance and accountability mechanisms, to ensure KVIs influence innovation decisions and support cross-project learning and assessment over time. KVI consideration needs to start long before a project is funded.

As a whole what is presented here is a starting point. The intention is not to be prescriptive but to offer a structure within which those working on KVIs and sustainability can start to talk, identify differences and commonalities, and clarify focus. It is expected that these processes will change and evolve as well as be refined and simplified as they get used.

To strengthen the framework's utility and adoption across the SNS community, the following **next steps** have been identified:

Validation and Alignment Mechanisms

- Develop a validation protocol for KVI proxies, establishing clear criteria for when and how proxies reliably represent intended social values that can be used similarly across all projects.
- Validate the causal links between technical parameters and social outcomes, demonstrating that technical metrics measurably contribute to the social values and sustainability goals the SNS community seeks to uphold. This should include defining and validating a formal technical to social value mapping protocol that explicitly connects technical KPIs to social KVIs and Key Values. A pilot validation phase would be beneficial, where specific technical parameters (e.g., network reliability) are measured against social outcomes (e.g., community trust) to ensure the framework is operationally sound.
- Further integrate KVI monitoring with Societal Readiness Levels (SRLs), ensuring that specific KVIs are gated by corresponding SRLs. This alignment will synchronize technical progress (TRLs) with societal acceptance and adaptation, ensuring value-based evidence aligns directly with technical development.

Practical Guidance and Tools

- Revise the consensus-based KVI/TRL/SRL matrices to provide actionable guidance for project managers on when and how to measure specific values. While a draft matrix

against TRL was produced in [XXX], it has not yet supported practical implementation, particularly for lower-TRL projects that struggle to operationalize KVIs. Similarly, the Matrix with SRL presented in this report needs validation.

- Develop a standard “KVI sentence” template to harmonize how KVIs are individually articulated across projects.
- Create clear flow charts and visual guides, ideally developed by professionals trained in visual communication, to illustrate the relationships between KPIs, UX metrics, and KVIs using concrete examples. These should especially be designed to be useful for newcomers to the topic.
- Clarify the scope and scales at which KVIs are intended to operate, simplifying the analytical framework for practitioners.
- Along with the above point, provide explicit guidance on whether KVIs should focus on 6G enablers, 6G effects, or both.

Resource Development

- Expand reference sheets to cover the remaining Key Values beyond the initial five developed in 6G4Society.
- Build a resource library containing existing repositories of social value indicators, proxy validation practices, and well-researched proxies that support specific value objectives.
- Formalize the indicator selection process to ensure all projects apply consistent methods when choosing from the hundreds of available indicators.
- Develop additional use case examples to ground discussions and demonstrate how KVIs connect to, but differ from, KPIs in practice.

Addressing Gaps and Tensions

- Strengthen focus on negative impacts and provide guidance for projects when technology does not work as intended or fails to fulfill intended outcomes.
- Develop frameworks for managing tensions or conflicts between different stakeholder needs from a “6G success definition” perspective or different value priorities.
- Clarify which sustainability elements are interconnected in ways that matter for 6G development.

These steps will continue transform the current foundation into a practical, validated toolkit that supports the SNS community in ensuring 6G technology measurably advances social values.

Overall, these efforts aim to ensure that technological progress drives both economic competitiveness, societal resilience, and environmental sustainability. By redefining success through the lens of societal values and sustainability, the 6G community can ensure that technological advancement serves the collective interest for the long term.

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APPENDIX A: VALUE DEFINITION SHEETS

Inclusivity in and by 6G (Digital and Social)

1. Key Value Definition

Pillar: Societal

KV: Inclusivity (Digital and Social)

Explanation of KV:

Inclusivity underscores the importance of ensuring that all individuals and groups, regardless of background, socioeconomic status, geographic location, or personal ability, have equal opportunities to access resources, participate in societal development, and have their voices heard in both physical and digital spaces [1] [2]. It is often described as bridging the digital divide [3]. **Social inclusivity** involves the ongoing effort to improve the terms of engagement for marginalized individuals and communities, ensuring equitable representation and participation in all aspects of society [4]. **Digital inclusivity** emphasizes global accessibility, affordability, and participation in the digital economy [1] [5] [6]. But, just as importantly, access alone does not provide inclusivity; it is also tied to elements like digital skills and rights needed for individuals or communities to make use of that access. The aim is to ensure that new technologies do not widen existing inequalities but instead help reduce the digital divide. It involves not just access to technology but also the capacity to use it meaningfully, shifting the goal from technological inclusion to equity in resulting well-being outcomes [7]. This includes digital literacy, cultural relevance, and addressing systemic barriers such as affordability, biased algorithms, and limited infrastructure [8] [9]. Achieving inclusivity requires that technologies and services be designed to be culturally sensitive, linguistically diverse, and adaptable to varied needs, empowering everyone to fully participate in and benefit from the opportunities of the digital age.

Relevance to 6G: Inclusivity is essential for 6G to be a truly transformative technology, but it risks widening the digital divide and creating new forms of social exclusion. Therefore, it is essential that inclusivity is a core consideration in the development and deployment of 6G from the outset.

2. Sub-Objectives

These sub-objectives outline specific areas where 6G can contribute to inclusivity.

- **Ensuring access, physical, economic, and social:** to technology and services for all, including underserved and marginalized communities, accounting for income disparities and geographic challenges. The aim is to ensure that no one is left behind or excluded in the digital age, regardless of where they live or their economic circumstances. The EU's Digital Decade targets, gigabit connectivity for everyone and 5G coverage in all populated areas by 2030, represent essential but insufficient conditions, as the quality, reliability, and cost of access determine whether connectivity enables or constrains participation [10].
- **Promoting digital literacy and skills:** to enable full participation in the digital society. This focuses on building human capacity, ensuring people have the confidence and knowledge to meaningfully use digital tools for their personal and professional growth and supporting individual agency [11] [8] [12]. The Digital Decade target of 80% of adults with

basic digital skills by 2030 reflects recognition that technical access without competencies produces exclusion.

- **Equitable outcomes:** It means equitable access to opportunities to obtain resources, participate in society, and benefit from services. It means designing systems that proactively challenge existing biases and removing barriers that hinder access. This requires systematic assessment of whether digital engagement produces tangible benefits distributed equitably across social groups [13].
- **Culturally sensitive and adaptable to diverse needs:** to design technologies and applications that respect unique (multi-)cultural contexts, (multi-)languages, and abilities, that are locally validated. Doing so fosters a sense of validation and belonging, allowing everyone to express themselves and participate [14] [7]. **This requires transparent and participatory processes** around deployment and local use-cases, consistent with EU environmental participation obligations under the Aarhus Convention and EIA Directive, that address concerns about not being heard, providing meaningful voice in infrastructure decisions that shape communities.
- **Supporting vulnerable and marginalized communities:** to empower groups facing systemic disadvantages, ensuring technology actively uplifts them and amplifies their voices and opportunities. It aims to build social resilience, solidarity, and foster a sense of belonging, strengthening the entire societal fabric [4] [15] [16]. **This includes accessibility by design** for persons with disabilities and older adults, as mandated by the Web Accessibility Directive, European Accessibility Act, and harmonized standard EN 301 549.

3. Stakeholders and Pain Points (What's at stake for who?)

Stakeholder	Their potential pain-points the KV could help illuminate
Individuals with disabilities	Lack of access to affordable 6G, lack of digital skills, exclusion from online services, and potential for discrimination in AI-driven systems. Interfaces, devices, and applications are often not designed with built-in accessibility features (e.g., for visual, auditory, motor, cognitive impairments), requiring costly retrofits or separate solutions.
Marginalised groups/ Civil Society Organizations	Affordability of access, cultural irrelevance/insensitivity, digital literacy gaps, lack of representation in design. Their voices and unique needs are often not considered during the design and development phases of 6G technologies, leading to solutions that do not address their specific challenges or promote genuine inclusion.
Governments and Public Sector	Securing sufficient public funds or incentivizing private investment for equitable 6G rollout, especially in unprofitable or underserved areas. Challenges in developing adaptable regulatory frameworks that ensure broad access while balancing innovation and market forces and preventing the exacerbation of existing digital divides.
Rural Communities	The high cost and logistical challenges of deploying dense 6G infrastructure in sparsely populated areas make them less commercially attractive for providers. Even if regional hubs exist, the last mile challenge often results in unequal access and resiliency issues due to limited provisions, hindering their ability to participate in the increasingly digital society. They also face the physical challenges of infrastructure.

Technology Developers/ Providers	Investing in accessibility features, cultural localization, and equitable deployment models that may not offer immediate or high commercial returns, impacting their commercial viability. Complexity in meeting the vast and often conflicting requirements for diverse user needs across a global user base, alongside ethical considerations like avoiding algorithmic bias.
Service Providers	Risk of services in less connected areas or with smaller market groups being unable to leverage 6G advancements, creating competitive disadvantages. Difficulty in reaching and serving diverse customer bases if digital inclusion is not prioritized, leading to potential loss of market share or legal challenges related to accessibility.

4. Impact

How Can Stakeholders Benefit (from engaging this value)?

Stakeholder	Positive and Negative Impacts	Scope and Significance of Impact
Individuals with disabilities	Greater access to information, education, and economic opportunities, leading to improved social connections and empowerment through digital participation. They gain a stronger voice and sense of belonging in the digital society. Negative Impact: Excluding individuals from online services or different interfaces, limiting their ability to participate in the digital economy, and potentially eroding cultural heritage, cost of adaptive technology, social isolation through interaction format shifts.	<i>The answers here depend on the use case or technologies being considered. Example answers could be:</i> Scope: Impact extends beyond pilot participants to inform accessibility standards that could affect similar groups across multiple EU MS. Significance: medium increase in access for individuals with visual impairments.
Marginalised groups/ Civil Society Organizations	They gain a stronger voice and sense of belonging in the digital society, leading to improved social connections and empowerment through digital participation. Negative Impact: Potentially eroding cultural heritage, widening the digital divide, new forms of social exclusion, lack of digital skills.	Scope: local community-level impacts. Significance (negative): leading to a modest erosion of trust in public institutions due to accessibility features.
Governments and Public Sector	More efficient and effective delivery of public services, improved citizen engagement and trust, and better overall social outcomes due to broader participation. This enhances democratic processes and strengthens social capital. Negative Impacts: citizens could be excluded from civic participation, lack of funds to deploy 6G or added costs to reach last mile areas, inferior services in poorer regions, vendor lock-in, new cybersecurity risks, decrease in in-person services.	Scope: providing evidence to policymakers at the EU level. Significance: Directly influence drafting of 1-2 key regulatory proposals.

Rural Communities	Enhanced social cohesion, stronger local economies, and greater ability to address local needs through inclusive digital solutions. This fosters more resilient and self-sufficient communities. Negative impact: widening the digital divide, new forms of social exclusion, lack of digital skills.	Scope: Operational changes in pilot municipalities with findings applicable to rural regions across the EU. Significance: Faster response time in hard-to-reach areas in southern Europe in simulated exercises.
Technology Developers/ Providers	Increased capacity to reach and support marginalized groups, stronger advocacy for digital inclusion, and greater impact through digital tools and collaborative platforms. This amplifies their ability to drive positive social change. Negative: May have limited resources to advocate for digital inclusion and monitor 6G's social impact.	Scope: Supply chain integration effecting regional market access for new entrants. Significance: Demonstrated pathways for technology providers to reach underserved markets.
Service Providers	Access to a larger and more diverse customer base, reduced operational costs through streamlined digital inclusion, and enhanced innovation driven by insights from diverse perspectives. This can lead to new market opportunities and improved brand reputation. Negative Impact: For businesses, this means difficulty in reaching and serving diverse customer bases and being excluded from 6G-enabled supply chains	Scope: Business model validation across diverse SME contexts, informing sector-wide adoption strategies. Significance: Large reduction in administrative costs.

What Actions or Decisions Will Result?

e.g. who makes decisions around this objective? What kind of decisions?

Stakeholder	Who would use the results of assessments within this value frame? How?
Individuals with disabilities	To better assess if a technology will provide them benefits. Individuals could use assessment results to make informed decisions about adopting 6G services, participating in digital literacy programs, and advocating for services that truly meet their needs. They can understand how to modify behaviour or daily routines for better engagement.
Marginalised groups/ Civil Society Organizations	To advocate for the rights of marginalized groups and monitor the impact of 6G on social inclusion. They could use assessments to gather evidence for advocacy campaigns, identify areas of concern, and hold technology providers and governments accountable for inclusivity commitments.

Governments and Public Sector	To develop policies and regulations that promote digital inclusion, such as encouraging development in areas where it is lacking or supporting literacy programs. They would use assessments to identify systemic barriers, allocate resources strategically, and enforce standards for equitable access and ethical AI deployment. Investment in 6G infrastructure and applications for public benefit by government agencies would be a key decision. Funding agencies could use insights to prioritize projects that address the digital divide and promote social equity. They would use assessment results to evaluate the potential social impact of proposed projects and allocate funding to initiatives that demonstrate measurable progress towards inclusivity objectives.
Rural Communities	Empower communities to co-own and integrate infrastructure, co-create relevant applications, and boost digital literacy to cultivate a thriving local tech ecosystem.
Technology Developers/ Providers	To design more accessible and inclusive 6G technologies and applications. They would use assessment results to identify and mitigate algorithmic biases, incorporate diverse user feedback into design iterations, and ensure built-in accessibility features from the outset. To provide evidence that the use case is effective in fostering inclusion.
Service Providers	To better assess if a technology will be of benefit to the communities they intend to serve and to better understand what kind of education/literacy is needed. To become more aware of specific requirements unique to different communities. They could use assessments to identify gaps in service accessibility or usability, inform pricing strategies for affordability, and tailor support programs to reach underserved communities. Could also use assessments to identify market opportunities in underserved areas and design inclusive products.

5. Implications for Technology and Use Case/PoC

Use Cases/PoCs

Objective	How might it affect use cases?
Ensuring equal access	Use cases should prioritize establishing and maintaining basic, affordable 6G connectivity as a fundamental right, ensuring everyone can access essential online services like emergency communications, telehealth, and education, regardless of their location or income. This directly combats the digital divide by ensuring a foundational level of participation. <i>Key Question: How does 6G explicitly ensure basic, affordable, and equitable connectivity for services that improve lives and livelihoods?</i>
Promoting digital literacy and skills	Use cases could centre on creating highly intuitive, personalized, and culturally relevant 6G-enabled platforms for digital skills training. Aim to empower individuals with the confidence and capability to fully participate in the digital economy, access better job opportunities, engage in civic life, and protect themselves from online harms. <i>Key Question: How do the activities foster digital literacy and confidence in communities to use 6G-enabled technologies?</i>

Equitable Outcomes	<p>Use cases should demonstrate that 6G technologies lead to measurable improvements in life outcomes for disadvantaged groups, not just access to a technology. This means validating that services reduce disparities.</p> <p>Key Question: How do the activities demonstrate that 6G reduces existing disparities and delivers tangible improvements in underserved communities?</p>
Culturally sensitive and adaptable to diverse needs	<p>Use cases would prioritize dynamic adaptation of digital content, interfaces, and services based on users' cultural background, language, and individual accessibility requirements.</p> <p><i>Key Question: How do the interactions supported by 6G adapt to and address diverse needs?</i></p>
Supporting vulnerable and marginalized communities	<p>Use cases should prioritise for the most vulnerable first. They could specifically address the unique challenges faced by vulnerable groups, such as providing discreet emergency support for individuals at risk of violence, enabling remote social support networks for the isolated elderly, or facilitating transparent aid distribution for displaced populations. This also includes platforms for amplifying their voices in policy discussions.</p> <p><i>Key Question: How do the technologies or interactions leverage capabilities that support the specific challenges faced by vulnerable and marginalised groups?</i></p>

Technology

What technologies are implicated most in this value? What tech features or enablers may reflect or even reinforce this problem?

This list in the following table is not complete, but an initial derivation from the enablers listed in discussion with the KVs based on what is being done currently in projects. It is expected to be expanded and refined, as a living resource.

Objective	Technological Enabler (lists built from existing project activities that tag this KV)
Ensuring equal access	<p>General:</p> <ul style="list-style-type: none"> ● AI as a Service (AlaaS) (Supports greater personalization and improves digital inclusion through application development) ● Global APIs (Facilitate easier and wider access to infrastructure and technologies) ● Lightweight computational solutions (Reduces latency, improving accessibility) ● Equipment agnostic/reusable solutions (Reduces hardware cost and dependency) <p>Geographic:</p> <ul style="list-style-type: none"> ● Non-Terrestrial Networks (NTNs) (Extends coverage in rural areas and mobility) ● Distributed Multiple-Input Multiple-Output (D-MIMO) systems (Enhance service availability in challenging environments) ● UAV-enabled networks (Provide localized coverage and high data rates in remote or disaster-affected regions) ● Temporary Connectivity Solutions in Rural Areas (Addresses unreliable connectivity in agricultural areas) <p>Economic:</p> <ul style="list-style-type: none"> ● Cost efficient network deployments, solutions.

Promoting digital literacy and skills	(none identified directly from projects, so far)
Equitable Outcomes	<ul style="list-style-type: none"> ● AI/ML integration (Enables remote work and industrial participation regardless of location) ● Automation technologies (Enhance job accessibility/efficiency) ● D-MIMO structures (Increase availability and quality of services like educational and cultural immersive products)
Culturally sensitive and adaptable to diverse needs	<ul style="list-style-type: none"> ● Immersive Remote Education (High-quality, low-latency content delivery for learning environments) ● AI-driven personalization and simplified interfaces (Enhances ease of use and accessibility)
Supporting vulnerable and marginalized communities	<ul style="list-style-type: none"> ● Advanced Sensing Technologies (Enable new interaction modalities like gesture recognition and adaptive interfaces) ● VR telepresence and remote control / Accessible User Interfaces (UI) (Including voice interaction to supplement limitations for people interacting with Digital Twins)

6. Key Value Indicators (KVI)s

Grounding Framework

What frameworks does the literature provide to support which KVI's matter for your objective/stakeholder/decision combination? What elements do your stakeholders say need to be covered?

This is an example of how this could work. It doesn't fully translate to the indicators provided here, as the indicators provided are selected examples from the projects, as much as possible. But ideally, there should be a direct correlation between research on what to monitor and what indicators are selected.

To monitor inclusivity in contemporary society, one must adopt a multi-dimensional framework that treats digital inclusion not as a peripheral technical issue, but as a core component of social inclusion where the focus is not on deficits but on initiatives, such as the ability to get new jobs, stay in touch with loved ones, or receive life threatening emergency warnings [17] [18]. Social inclusion is defined by an individual's ability to participate fully in their social world, a goal that is increasingly dependent on the expansion of individual capabilities within digital environments, and requires not just immediate solutions but the ability to address the systemic dynamics that create the divides in the first place [19]. It is grounded not in if a person has technology at their house but if they can use that technology in the ways that they need to [20]. Therefore, monitoring efforts must look beyond mere infrastructure to evaluate different levels: physical access to broadband and devices; the acquisition of digital literacy and skills; and the actual ability to derive socio-economic benefits from that access [21]. It also requires looking at uptake of services offers, trust in those services, improved outcomes such as education levels or jobs, and increased innovation in the domain [22] [23]. In the European Union, for instance, 44% of citizens lack the foundational digital skills necessary to thrive in a digital economy, underscoring a persistent divide where educational attainment and occupational status remain the primary barriers to social and economic inclusion [24]. A comprehensive monitoring approach should integrate infrastructure investment, educational programs, and inclusive (city, community, technology) planning [25]. This also means looking at specific demographic features like income, occupation, and rural/urban areas, which have been identified as critical to bridging this gap [26].

Monitoring inclusivity should prioritize equitable outcomes and cultural agency over simple participation metrics. This requires moving toward a strategy that centres the experiences of historically marginalized communities through intentional community engagement and the

recognition of intersectionality. What is considered about accessibility needs to also be tailored to specific technology, where emerging technology is showing to require different types of actions and monitoring than traditional technology [27]. To prevent the loss of autonomy for the elderly, disabled, or low-income populations in a digitised society, monitoring must account for the presence of diverse voices at the design table. This is particularly important as policy and decisions are often data driven, which, without participation, makes those on the wrong side of the divide doubly invisible. Effective inclusion is not achieved through a one-size-fits-all approach; it requires tailoring to unique cultural situations to ensure interventions meet the specific decision-making needs of diverse communities.

KVI Formulation

Exemplar KVIs: These are not intended to be standards or to be used by all projects or necessarily ones that actually get used. These exemplars offer ideal qualities that can be imitated to develop good KVIs. Each is presented as a stakeholder/objective/decision pairing (e.g. what stakeholder is being considered or who might use it, and the objective within the value) to help narrow the focus.

KVI	Stakeholder Impacted	Objective Aimed At	Decision it Supports
Increase in coverage footprint (example from 6G-Senses) Increased service quality (example from Origami) Affordable high speed and low latency network connectivity even in low-density populated areas (example from 6GNTN).	Rural Communities & Service Providers	Ensuring equal access	Supporting technical design choices, focused on the infrastructural improvements needed within the testbeds. (Dimension 1)
Rationale: This directly measures the quality and reliability of access being delivered to Rural Communities. Rural communities suffer most from the digital divide, characterized by sparse infrastructure, geographical barriers, and sparse populations that make traditional network deployment economically unviable. Low service availability or high cost means unreliable coverage and thus access to essential services reinforcing social and economic isolation.			

KVI	Stakeholder Impacted	Objective Aimed At	Decision it Supports
Accessibility for All: Easiness of using accessible hardware / solutions example (example from 6G-XR) Perceived usefulness of the provided service, by demographic (example from 6G-Path). The enhanced communication services accessible to end users with diverse abilities, needs, and skills (from 6G-Cloud).	Individuals with disabilities	Culturally sensitive and adaptable to diverse needs	To assess if a technology will provide people with different accessibility needs benefits and what design decisions can be made to increase this. (Dimension 2)
Rationale: Move beyond mere availability of technology to measuring its true usability and effectiveness in driving digital inclusion and achieving true equity. A high-performing network is useless if the device required to access it is difficult or impossible to operate or requires prohibitively expensive proprietary interfaces.			

KVI	Stakeholder Impacted	Objective Aimed At	Decision it Supports
<p>Percentage of who is involved in the trials in comparison to who should be involved based on the target community (example from FIDAL)</p> <p>Percentage of the population that has access to the solution/service (example from HEXA-X-II)</p> <p>Digital literacy (Target-X)</p>	Marginalised groups / Civil Society Organizations & Rural Communities	<p>Supporting vulnerable and marginalized communities</p> <p>Promoting digital literacy and skills</p>	<p>To assess if their concerns are being considered as they monitor the impact of 6G on their communities.</p> <p>(Dimension 3)</p>
<p>Rationale: This measures a project's commitment to inclusivity in its development process, focusing on procedural equity. These groups are often excluded from or tokenized in technology development processes. Without their genuine involvement, the 6G solution risks failing to address their real-world barriers or, worse, creating new ones.</p>			

KVI	Stakeholder Impacted	Objective Aimed At	Decision it Supports
<p>Inclusivity by design metrics: Proportion of development decisions informed by underserved community input [28].</p> <p>Policy Alignment Indicators: Number of regional or national policy frameworks the solution is designed to support [29].</p>	Governments and Public Sector, Service Providers	Equal Access and Equitable Outcomes	<p>Identify systemic barriers; allocate resources strategically; to prioritize projects.</p> <p>(Dimension 4)</p>
<p>Rationale: Captures whether 6G solutions are designed <i>with</i> marginalized communities rather than <i>for</i> them, ensuring technologies address real needs and can be adopted by public services. By tracking community input in development decisions and alignment with policy frameworks, it provides early evidence that solutions will be implementable by governments and service providers at scale.</p>			

KVI	Stakeholder Impacted	Objective Aimed At	Decision it Supports
SRL readiness level/ Digital readiness assessment (through infrastructure assessments and stakeholder capacity evaluations) [30].	Governments and Public Sector	Equal Access and Equitable Outcomes	<p>Encouraging development in areas where it is lacking or supporting literacy programs; Know when to invest in 6G infrastructure and applications for public benefit.</p> <p>(Dimension 5)</p>
<p>Rationale: Communities need the foundational infrastructure and capacity to absorb and sustain 6G technologies. Identifying gaps that must be addressed before deployment is key to this. By assessing societal readiness alongside technical readiness, it helps governments target investments in infrastructure and literacy programs where they're most.</p>			

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Trust and Trustworthiness in 6G

1. Key Value Definition

Pillar: Societal

KV: Trust/Trustworthiness

Explanation of KV:

Trust relates to feelings of control, a stakeholder's willingness to be vulnerable to the actions of another, and confidence that the system will act as intended [1] [2]. It correlates directly with economic growth, increased security and justice, solidarity and higher levels of happiness and freedom, and is tied to individual economic status [3] [4] [5]. Trust is the cornerstone of collaboration and knowledge sharing within groups and is needed to counter social fragmentation. In communities, fostering trust is essential for the adoption of technology and compliance with policies [6]. Yet, how it is understood varies by discipline: sociologists view it as relational, psychologists as cognitive, and economists as calculative [7]. Importantly, trust is dynamic and context-specific, shaped by factors such as transparency, ethics, security, control, reputation, feeling heard and shared expectations [8] [9]. It is deeply shaped by societal needs, power dynamics, and lived experiences, is not a universal standard. In particular, different communities have varying perspectives on what makes technology trustworthy [10].

Trustworthiness is a multifaceted concept encompassing interpersonal trust (between individuals), group trust (in organizations and communities), institutional trust (in governments and corporations), and generalized social trust (in broader systems). Others categorise it as horizontal trust (trust in fellow citizens) and vertical trust (trust in institutions and hierarchies), where vertical trust, grounded in systems based on reciprocity and fairness, is necessary for other forms of social trust to flourish [11] [12] [5] [13].

Either way, Trust is foundational for social and economic interactions. Interpersonal trust includes balancing skills, benevolence, and integrity. This extends to 6G-enabled products and services: they must be designed to behave in this way to be accepted [1]. Institutional trust is the belief that institutions act according to the expectations of the public. This extends to the technology used; if the technology fails or is too opaque (e.g. 5G, AI) then the public's overall confidence in institutions can be damaged [14] [15]. Generalised trust, the idea that most people can be trusted even strangers (e.g. those making 6G, those using 6G), is key to participative behaviours and one of the strongest predictors of digital trust [16].

Trust is also socio-technical construct representing a user's willingness to be vulnerable to a technology system despite the inability to monitor it [8]. It blends human trust derived from interpersonal models (e.g. benevolence and integrity) and system trust, which is rooted in technology models (e.g. functionality, helpfulness, and reliability) [17]. 6G will connect an increasing number of tools and services, new, hybrid human-technology forms of trustworthiness likely need to be defined, that allow different forms of negotiation and assessment needed to enable trust [1] [18]. It is central for the successful implementation of new technologies, as it affects perception, engagement, and impact. Reliable, secure, and transparent systems such as those that protect privacy, ensure communication security, and clearly communicate how they function help foster this trust. Maintaining this value requires transparency, user agency, and ongoing dialogue to ensure that digital transformations respect human values and long-term societal wellbeing [19] [10].

Relevance to 6G: Trust is paramount for the widespread adoption and societal benefit of 6G. Policy and industry goals must prioritize building trust to overcome potential user resistance and ensure the technology is seen as a positive force. It also potentially requires new forms of technology design and revisiting what it means to develop trustworthy technology and services.

2. Sub-Objectives

- **Maintain public trust and confidence in services:** Employ 6G in a manner that maintains and enhances public trust in fellow persons, businesses, agencies and the technologies they use [14] [12].
- **Enhance the security, reliability, and resilience of networks and services:** Ensuring that technology consistently meets expectations fosters confidence. They provide the objective assurances necessary for users to accept vulnerability in digital interactions [15] [1] [7].
- **Promote transparency, reciprocity, and user control in services:** When people understand how systems make decisions, it fosters a sense of control and predictability, which are key to trust. Addressing how 6G (and related technologies, like AI) might influence choices or opinions, transparency helps alleviate fears of manipulation, strengthening trust in digital interactions [20]. This includes fostering ongoing dialogue with stakeholders.
- **Establish clear accountability and governance frameworks:** People are more likely to trust and adopt technologies when they perceive that those technologies are developed and deployed responsibly, with human well-being and societal impact as a priority, beyond compliance. Clarity of responsibility, e.g. defining who is responsible when things go wrong, fosters a sense of reassurance and reducing uncertainty. When clear frameworks exist for recourse and redress, it signals a commitment to fairness and justice, which enhances public acceptance and adoption and reinforces trust in organisations and institutions [20] [12] [14].
- **Maintain Integrity:** Integrity signifies a consistent adherence to strong moral and ethical principles, even when unobserved. This commitment builds trust by assuring stakeholders that the organization acts with honesty and fairness, reduce minimum impacts, not just focus on compliance. It means being truthful about intentions, capabilities, and limitations [1] [3] [7] [19].

Trust is also directly tied to maintaining economic and social prosperity and wellbeing [3] [4] [5]. It is also tied to foster collaboration and knowledge sharing [6].

3. Stakeholders and Pain Points (What's at stake for who?)

Stakeholder	Their potential pain-points the KV could help illuminate
Individual Users	Overall disconnect between expectations and confidence. Concerns about erosion of privacy (e.g. data breaches, surveillance), increased vulnerability, unreliable services, loss of autonomy and agency (e.g. lack of control over their data), generalized loss of trust in technology as being beneficial, lack of perceived value-exchange from services.
Businesses (using 6G)	Trust is a business imperative to maintain a competitive advantage. Risks of cyberattacks, data loss, operational disruptions due to unreliable 6G infrastructure, legal liabilities related to data privacy, reputational damage and loss of customers, operational disruptions and financial losses. Gap between high level principles/policies and actionable/practical implementation. Fear of being accused of ethics-washing.
Governments and Regulatory Bodies	Loss of public confidence and legitimacy due to challenges in ensuring compliance with regulations, preventing misuse of 6G for malicious purposes, and maintaining public order in a hyper-connected society, challenges in keeping accountability and security frameworks from falling behind innovation. Need to navigate risk-based approaches without stifling economic or social growth.

Technology Providers	Market rejection and competitive disadvantage leading to loss of customers, negative publicity. Legal and business liability for damages resulting from security breaches, privacy violations, or algorithmic biases.
Society as a whole	Erosion of social cohesion and democratic values, potential for manipulation, loss of trust in institutions and fellow members of society.

4. Impact

How Can Stakeholders Benefit (from engaging this value)?

Stakeholder	Positive and Negative Impacts
Individual Users	High levels of trust enable individuals to enjoy greater perceived control over their data, lives, better life chances, access to economic benefits. Users also benefit from personalised experiences and improved service delivery when they are willing to share data with trusted providers, as well as a safer digital environment. Negative Impacts: When trust is violated or low, users experience vulnerability and loss of control, unheard, and experience raised anxiety.
Businesses (using 6G)	Trust offers a competitive advantage, increased consumer loyalty, increased revenue. Trust in technology can lead to enhanced productivity while respecting human creativity. Negative Impacts: data breaches can be catastrophic to trust, businesses perceived to engage in ethics-washing face public backlash, The complexity of 6G and AI makes accountability difficult to assign.
Governments and Regulatory Bodies	Improved ability to ensure security and protect citizens, better governance of 6G technologies, and increased public trust in technological advancements, improved efficiency and objectivity of public administration. Negative Impacts: Malfunctioning technical systems can lead to loss of public confidence. Low trust leads to social fragmentation, political disengagement, and lower voter turnout. Over-reliance on private technology providers can lead to a loss of institutional memory and governance capacity.
Technology Providers	Stronger brand reputation, increased market competitiveness, and long-term sustainability by fostering user loyalty and attracting investment, motivation to shift to a human-centric approach. Negative Impact: the need to translate social factors into technical design, need to provide accountability mechanisms, fear of accountability gaps.
Society as a whole	Greater societal acceptance of 6G, reduced digital divide based on trust concerns, and a more ethical and responsible deployment of advanced technologies. Improved economic growth and social solidarity. Negative Impacts: Distrust fuels anti-establishment sentiment. It also exacerbates the digital divide.

What Actions or Decisions Will Result?

e.g. who makes decisions around this objective? What kind of decisions?

Stakeholder	Who would use the results of assessments within this value frame? How?
Individual Users	To make informed decisions about adopting and using 6G services based on their level of trust, when to share data, when to opt-out of features, and provide manual verification of services and information.
Businesses (using 6G)	To make informed decisions about adopting and investing in 6G services, to ensure the reliability and security of their 6G services and to communicate these assurances to their customers.

Governments and Regulatory Bodies	To develop effective regulations and standards that promote trust in 6G technologies and protect user rights, decide what technologies to promote or prohibit, build adaptive regulations,
Technology Developers	Design choices by engineers, e.g. to design and build more secure and privacy-preserving 6G systems and applications, adjust level of human oversight, develop assurance mechanisms that address public wariness.
Society as a whole	Safeguard the social contract and implicit social agreements, define the digital good, clarify what it means to respect the laws. They could decide to revoke the political mandate for 6G or decide to participate in the innovation process.

5. Implications for Technology and Use Case/PoC

Use Cases/PoCs

Objective	How might it affect use cases?
Maintain public trust and confidence in services	<p>Use cases could focus on showing how users or businesses interact with services in a way that reinforces their belief in the service's fairness and safety, and consider what happens if trust is not maintained. Use cases involving sensitive (personal) data will require a much higher emphasis on trust and security in their design and deployment, where the use case focuses on designing for trust as a central core. Use cases could focus on what users consider tangible returns.</p> <p><i>Key Question: What interactions, from the public's perspective, build or erode trust, and how can we design those interactions to foster confidence?</i></p>
Enhance the security, reliability, and resilience of networks and services	<p>Use cases could focus on how various actors are able to actively protect and restore the operational integrity of the system against threats in ways that offer continuity on their sides. They could focus on how critical services deliver consistent and dependable results for stakeholders doing their jobs, especially in high-stakes environments. They could also focus on user or societal risk perception, support users in identifying and mitigating vulnerabilities, and ability of users to implement, understand, and demonstrate security mechanisms. Technical resilience requires proactive trust repair strategies.</p> <p><i>Key Question: What interactions are necessary to proactively prevent, detect, respond to, and recover from operational disruptions? How does the system dependably deliver the expected outcome?</i></p>
Promote transparency, reciprocity, and user control in services	<p>These use cases could focus on consumer, user, and public understanding of systems and services and their ability to predict resulting experiences. They could focus on how stakeholders can gain insight into the logic, data, and outcomes of systems, e.g. from explanation or audit. They could also include situations where bias could emerge and thus be mitigated. Use cases could focus on if technology or services consistently meet stakeholder expectations, both in terms of quality of service as well as effects on their ability to act.</p> <p><i>Key Question: What interactions enable stakeholders to understand the system, verifying its fairness, accuracy, and adherence to policy?</i></p>

<p>Establish clear accountability and governance frameworks</p>	<p>Use cases could focus on working with stakeholders to establish how they want to approach ethical standards and be set up such that it is possible to assess or anticipate if stakeholders see the standards as being met.</p> <p>Use cases here are less about direct external user interaction and more about internal organizational processes and system capabilities that support oversight, auditability, responsibility, and adherence to rules. Use cases could focus on ensuring frameworks of responsibility are able to be defined, are clear, and able to be acted upon. They could also focus on engaging policy and standards so as to find gaps or further clarify or build consensus as to what it means to act within such a framework.</p> <p><i>Key Question: What technological design features alleviate negative ethical concerns from stakeholders? What internal processes and system features are required to clearly define responsibilities, track actions, and ensure adherence to established policies and ethical guidelines?</i></p>
<p>Maintain Integrity</p>	<p>Use cases should both technically and socially preserve the accuracy, completeness, and trustworthiness of data and information throughout its lifecycle, protecting against malicious or accidental alteration. Use cases should help build the public perception that an organisation adheres to acceptable principles, honesty, and reliability, rather than acting only out of a desire for profit or stop at basic legal compliance. They should focus on public communication.</p> <p><i>Key Question: How can 6G management processes and technologies ensure technical and social integrity?</i></p>

Technology

What technologies are implicated most in this value? What tech features or enablers may reflect or even reinforce this problem?

Objective	Technology Enablers
<p>Maintain public trust and confidence in services</p>	<ul style="list-style-type: none"> ● Explainable AI, to provide human-interpretable explanations ● Human-machine intent interface design, to include human concerns. ● Intent-based networking, to allow users to declare high-level goals ● Secure and privacy-enhanced machine learning; Privacy-Preserving Data ● Holographic/Immersive Visualization, to foster interpersonal trust, cooperation, and shared understanding
<p>Enhance the security, reliability, and resilience of networks and services</p>	<ul style="list-style-type: none"> ● Secure and privacy-enhanced machine learning ● Zero-Trust Security & SDP ● Privacy-Enhanced AI Models ● Trusted Execution Environment ● Post-Quantum Cryptography and related security services, for long term data integrity ● Anomaly Detection, to identify and respond to cyber threats and hardware failures in real-time. ● Distributed MIMO, to enhance service availability and reliability ● Streamlined network function interfaces & interaction ● Trustworthy 3rd party management ● Physical Layer Deception ● Multi-domain/Multi-cloud federation

Promote transparency, reciprocity, and user control in services	<ul style="list-style-type: none"> • Explainable AI, to provide human-interpretable explanations • Auditable systems, to provide • Intent-based networking, to allow users to declare high-level goals • Self-Sovereign Identity, so users have complete ownership of their data • User-Centric Privacy Interfaces, users to view and adjust privacy settings
Establish clear accountability and governance frameworks	<ul style="list-style-type: none"> • Trustworthy AI; Sustainable AI/ML-based control; Trustworthy AI/ML-based control • Trustworthy 3rd party management, Level of Trust Assessment Function, to monitor service health and provider reputation • Smart Contracts, to ensure all parties are held accountable
Maintain Integrity	<ul style="list-style-type: none"> • Sustainable AI/ML-based control • Trustworthy AI/ML-based control • Privacy-Enhanced AI Models; Secure and privacy-enhanced machine learning; Privacy-Preserving Data Processing & Collecting • Physical Layer Security, to protect transmissions against eavesdropping • Continuous Authentication, to verify user identity • E2E context awareness management • Trusted Execution Environment (TEE) • Digital Twin (DT) Simulation, to test in safe environments

6. Key Value Indicators (KVI)

Grounding Framework

What frameworks does the literature provide to support which KVIs matter for your objective/stakeholder/decision combination? What elements do your stakeholders say need to be covered? *For this exemplar document, see key value, objectives, and references. Were there to be a specific use of this for a project, it is expected that additional research would be done to explain why each indicator was chosen, or how the selected indicators, as a group, are interrelated to the broader project goals. See the inclusivity sheet for a partial example.*

KVI Formulation

Exemplar KVIs: These are not intended to be standards or to be used by all projects or necessarily ones that actually get used. These exemplars offer ideal qualities that can be imitated to develop good KVIs. Each is presented as a stakeholder/objective/decision pairing (e.g. what stakeholder is being considered or who might use it, and the objective within the value) to help narrow the focus.

KVI	Stakeholder Impacted	Objective Aimed At	Decision it Supports
System resilience against faults and attacks, via measurements and redundancy to detect and mitigate errors (example from 6G-DISAC)	Technology Developers	Enhance the security, reliability, and resilience of networks and services	Where to invest resources in system hardening and resilience improvements for service reliability; identify technological vulnerabilities (Dimension 1)
Ensure security in communication between remote and application, via tests (example from NANCY)			
Number of downtime events where there's no identifiable cause (example from HEXA-X-II)			

Rationale: Addresses failures and measures consistent performance quality; together they capture worst-case resilience and routine reliability. Technology developers need concrete metrics to demonstrate that systems embody the technical features that form the foundation of system trust. When technical systems fail, there is often loss of public trust in institutions, not just trust in the technology.

KVI	Stakeholder Impacted	Objective Aimed At	Decision it Supports
Level of Trustworthy, an index that measures user-centric perspectives on Safety, Security, Privacy, Resilience, and Reliability (example from Safe-6G) Reported user confidence in the digital devices, systems, and services used in the use-case development and operation (example from TrialsNet)	Individual Users	Maintain public trust and confidence in services	Assess if they feel safe using the technology and thus want to adopt it; assess what kinds of interactions and feedback they would like to provide (Dimension 2)

Rationale: Trust fundamentally involves a stakeholder's willingness to be vulnerable to the actions of another and confidence that the system will act as intended. These indicators directly measure whether users are willing to adopt that vulnerable position.

KVI	Stakeholder Impacted	Objective Aimed At	Decision it Supports
Operators expressing confidence and trustability in digital devices, systems, and services and their overall transparency/understandability (example from 6G-Path, HEXA-X-II) Trust in the system's behaviour and governance, assessed via expert evaluation, subjective feedback gathered from trials (example from FIDAL)	Businesses (using 6G)	Promote transparency, reciprocity, and user control in services	Can an institution trust the system enough to invest or collaborate further? Can we safely vouch for this system to our citizens? (Dimension 3)

Rationale: Municipal/operator confidence is a proxy for the perceived risk for communities. Indicator 1 addresses technology trust, while indicator 2 captures human trust, which supports assessment of if there is sufficient institutional trust to proceed.

KVI	Stakeholder Impacted	Objective Aimed At	Decision it Supports
Expert reviews and simulations that solutions that can manage risk that would impact fundamental rights [20].	Governments and Regulatory Bodies	Establish clear accountability and governance frameworks	Do we grant a license to the 6G service? Do we mandate further accountability and responsibility mechanisms? (Dimension 4)

Rationale: Trust is often a reflection of the tangible returns citizens receive for their contributions, such as high-quality education and healthcare. Regional systems maintain trust when they are perceived as suitable and appropriate for society, balancing innovation with social norms. Overall, the capacity of a regional system to redistribute value is compromised if it cannot be held accountable for systemic failures.

KVI	Stakeholder Impacted	Objective Aimed At	Decision it Supports
<p>Evidence of conformity with ethical principles, legal requirements, and post market monitoring plans before full-scale market entry [20].</p> <p>Assessment of if citizens feel the value exchange is fair, via survey of general citizens after demonstration of whether the benefits they imagine receiving (e.g., better services) justify the risks they would have to take (e.g., sharing personal data) [13].</p>	Governments and Regulatory Bodies; Society as a whole	Maintain Integrity	<p>Whether current ethical and legal frameworks are sufficient or require updating.</p> <p>If additional safeguards or monitoring requirements are needed before authorization</p> <p>(Dimension 5)</p>
<p>Rationale: A key indicator is whether vertical trust (trust in the hierarchy/institutions) is strong enough to foster horizontal trust (trust between fellow citizens), which allows value to flow freely across social networks.</p>			

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Safety as a Societal Value for 6G

1. Key Value Definition

Pillar: Societal

KV: Safety

Explanation of KV:

Safety is the protection of individuals from harm and ensuring they are not exposed to vulnerable situations. It consists of public interventions designed to assist individuals, households, and communities in managing risk and providing support to those who cannot provide for themselves. Safety focuses on the absence of physical, mental, environmental, and emotional harm. Safety requires a multi-layered approach to the protection of individuals, spanning **economic security, occupational safety, human security, digital rights, and internal security**. Protection is framed not only as the prevention of physical or intentional harm but also as the mitigation of subjective perceptions of lack of safety and the reduction of systemic vulnerabilities [1] [2] [3]. It also has to consider that exposure to harm and vulnerability is unevenly distributed across the population, with vulnerable and marginalized populations often taking the greatest burden [4]. Safety is also when individuals and communities benefit from proactive measures, robust and resilient systems, and readily accessible resources that minimize the likelihood and impact from hazards, threats, and crises. This includes not only protecting individuals and communities from immediate danger and vulnerable situations but also fostering an environment of security, well-being, and trust that enables them to thrive and recover effectively in the face of adversity.

2. Sub-Objectives

These sub-objectives outline specific areas where 6G can contribute to enhanced safety.

- **Protection from hazards and risks:** Enhance resilience against natural disasters, crime, and other hazards (e.g. environmental, food health). This includes safety from terrorism, crime, cyberattacks, environmental hazards, as well as the ability to anticipate future systemic shocks, such as public health emergencies or natural disasters, as well as the maintenance of free movement across borders [5] [1]. Resilience, adaptation, and mitigation, are all key aspects of this element of safety, especially as they relate to supporting livelihoods, food security, and disaster recovery [6]. Similarly, this includes the protection of digital harm, such as the harmful effects of AI, constant surveillance, and automated systems that can function without human command [7].
- **Workplace and Home Safety:** Create safer living and working conditions through real-time monitoring and proactive risk mitigation. Minimize injuries, fatalities, trauma, and long-term health issues caused by hazards. This includes reduced work-related accidents and illnesses, increased safety throughout the R&D phases, protection in remote work, and the protection from psychosocial risks like work-related stress or bullying [4] [8] [9].
- **Freedom from social risks:** Contribute to safer communities by improving public safety (e.g., enhanced surveillance for crime prevention, faster emergency response) and mitigating risks of violence through improved communication and awareness. This includes protection of vulnerable groups such as migrant workers, platform workers, children, and women, who face higher levels of insecurity and inequalities, cultural and language barriers, different forms of isolation and exclusion, and are at more risk to experience poverty or violence [1] [10] [4] [9]. It also involves the reduction of people at risk of poverty and social exclusion, equal and adequate access to social protection systems [10].
- **Access to basic needs and a reliable social security system:** Ensure equitable access to essential goods and services required for a life in dignity (e.g., efficient delivery of aid, remote monitoring of critical infrastructure, food, child care, energy/heat, lighting, minimum

income, housing), and to support robust social safety nets through improved communication and information sharing [11] [12] [13] [14]. In the context of disasters or climate change, social protection is viewed as the first line of defence, providing assistance to help vulnerable groups absorb shocks and recover faster [6]. Often care is not accessed because of administrative complexity.

- **The perception of safety and feeling secure in daily life:** Foster a sense of security and well-being enabling individuals and communities to flourish without constant fear or vulnerability [2]. This relates to social cohesion and safe public spaces where people see the safety signals they expect [15] [16]. This includes designing public spaces in ways that support this perception.

Relevance to 6G:

If the underlying 6G system is not designed with safety in mind, vulnerabilities in one part of the system could cascade and expose individuals to harm or could erode the general well-being of individuals and communities. 6G offers an opportunity to proactively monitor and build awareness of potential harms and vulnerabilities in the world that are faced by stakeholders. This means not just reacting to threats but anticipating them during the design phase.

3. Stakeholders and Pain Points (What's at stake for who?)

Stakeholder	Their potential pain-points the KV could help illuminate
Individuals/ Citizens	Impacted by personal safety, health, and well-being. Exposure to risks from disasters, accidents in public or workspaces, lack of timely warnings, and inefficient emergency response. Feeling safe in their neighbourhood.
Workers	Protection from dangerous working conditions. Injuries and fatalities in the workplace due to hazardous conditions, lack of real-time safety information, and inadequate training or remote support. Protection from work-related musculoskeletal disorders due to non-ergonomic postures
Consumers	Impacted by product safety and the safety of services.
Vulnerable Groups	Including children, the elderly, and those with disabilities, who may have specific safety needs, heightened risks during emergencies, difficulties in accessing timely information and assistance, or greater susceptibility to harm.
Businesses/ Organisations	Need to comply with safety regulations or implement safety protocols to ensure the safety of their employees and customers. Costs associated with workplace accidents, legal liabilities, reputational damage, and the need for more effective safety protocols.
Emergency Response Teams	Challenges in coordinating efforts, lack of real-time situational awareness, difficulties in accessing affected areas, and inefficient resource allocation.
Governments/ Policymakers	Responsible for setting and enforcing safety regulations and ensuring public safety, and the burden of managing disaster response and recovery.
Communities	Crime rates, crises, and disasters are negatively connected to vibrant communities.

4. Impact

How Can Stakeholders Benefit (from engaging this value)?

Stakeholder	Positive and Negative Impacts
Individuals/ Citizens	Increased safety and security in their communities, timely warnings for impending disasters, faster and more effective emergency response, and reduced risk of accidents in public spaces. Negative Impact: added surveillance, loss of freedom or control of data, loss of autonomy.

Workers	Reduced workplace accidents and safer work environments. Reduced incidence of work-related musculoskeletal disorders. Negative Impact: Over-reliance on technology leading to de-skilling of human safety oversight and intervention. Lack of trust in the technology due to excessive monitoring and surveillance.
Consumers	Improved product safety and the safety of services. Negative Impact: increased need for expensive cloud-based services, increase loss of control of personal data, inability to repair items.
Vulnerable Groups	Improved access to timely warnings and assistance during emergencies, tailored safety information, and enhanced tailored protection. Negative Impact: over-surveillance of an already marginalised group, increased costs, harms from automated decision making that is trained on data from elsewhere, increased critical infrastructure dependence.
Businesses/ Organizations	Reduced workplace accidents and associated costs, improved productivity through a safer workforce, enhanced reputation, and compliance with safety regulations. Negative Impact: The cost of implementing and maintaining sophisticated 6G safety systems may be prohibitive for some organizations or communities; Data overload from continuous monitoring potentially hindering timely and effective analysis and response.
Emergency Response Teams	Enhanced situational awareness and risk assessment, improved communication and coordination, faster response times, more efficient resource allocation, and increased safety for responders themselves. Negative Impact: potential for system failures or communication breakdowns during critical safety events, cost of implementing and maintaining sophisticated 6G safety systems; Data overload from continuous monitoring potentially hindering timely and effective analysis and response.
Governments/ Policymakers	More effective public safety management, reduced burden on emergency services, better enforcement of safety standards, and increased citizen trust. Negative Impact: increased critical and sensitive data storage and processing needs. Increased cybersecurity risks.
Communities	The overall safety of a community affects its social cohesion and quality of life. Negative impact: the cost of implementing and maintaining sophisticated 6G safety systems may be prohibitive for some communities; increased surveillance.

What Actions or Decisions Will Result?

e.g. who makes decisions around this objective? What kind of decisions?

Stakeholder	Who would use the results of assessments within this value frame? How?
Individuals/Citizens; Communities	Understand the benefits and limitations of 6G safety technologies, leading to greater trust and willingness to adopt them. Understand how to modify behaviour or daily routines.
Workers	To assess the impact of 6G technologies on worker safety and inform best practices, identify training needs, and prevent safety failures.
Consumers	Make informed purchasing decisions, choosing solutions that genuinely enhance their safety and peace of mind, avoiding ineffective or risky technologies.
Vulnerable Groups	Understand the benefits and limitations of 6G safety technologies, leading to greater trust and willingness to adopt them and advocate for their specific needs.

Businesses/ Organisations	To make informed decisions about investing in 6G safety solutions and implementing them effectively in the workplace. Procurement of 6G-enabled equipment and systems.
Emergency Response Teams	To evaluate the effectiveness of 6G tools in improving disaster preparedness, response, and recovery.
Governments/ Policymakers	To develop standards and guidelines for the deployment and use of 6G in safety-critical scenarios. Investment in 6G infrastructure and applications for public safety by government agencies. Prioritize funding for 6G initiatives
Tech Developers	To identify weaknesses or gaps in a use case's ability to deliver on safety objective. Provide evidence that the use case is effective in creating safer conditions. Use findings to implement safeguards and ethical guidelines.

5. Implications for Technology and Use Case/PoC

Use Cases/PoCs

Objective	How might it affect use cases?
Protection from environmental hazards and risks	<p>Use cases should enable the anticipation of hazards before they cause significant harm. They should prioritize use cases with a direct and significant impact on preventing harm and improving safety, such as real-time worker fatigue monitoring, and drone-based disaster damage assessment, and situational awareness systems for localized hazards. The design and capabilities of 6G applications are driven by the specific safety needs of users and communities rather than solely by maximizing technical performance metrics like speed or capacity. They should prioritize robustness and alternative pathways to ensure continuous operation even under stress.</p> <p>Key Question: How can 6G-enabled systems provide transparent and actionable insights to stakeholders, allowing them to understand and identify potential hazards and risks?</p>
Freedom from social risks	<p>Use cases should improve understanding of evolving public safety situations, provide ways for citizens to report concerns or seek help, for authorities to disseminate vital information, and reduce the likelihood of criminal activity or violence.</p> <p>Key Question: How can 6G support the necessary identification, understanding, and communication of public safety concerns?</p>
Access to basic needs and a reliable social security system	<p>Use cases are developed with a strong focus on ensuring that safety benefits are accessible to all individuals and communities, including those with limited digital literacy, disabilities, or in underserved areas.</p> <p>Key Question: What deliberate strategies can be engaged to proactively identify and dismantle any barriers to potential safety benefits?</p>
The perception of safety and feeling secure in daily life	<p>Enhance the sense of security and well-being through reliable communication, access to support networks, and technologies that promote mental, physical, and emotional safety.</p> <p>Key Question: How can 6G-enabled technologies provide the public with a clear sense of control, promoting a sense of safety?</p>

Technology

What technologies are implicated most in this value? What tech features or enablers may reflect or even reinforce this problem?

This list in the following table is not complete, but an initial derivation from the enablers listed in discussion with the KVs based on what is being done currently in projects. It is expected to be expanded and refined, as a living resource.

Objective	Technology Enabler
Protection from environmental hazards and risks	<ul style="list-style-type: none"> • Monitoring and Telemetry Framework • Programmable Network Monitoring and Telemetry • Anomaly Detection and Classification • Network Digital Twins • Threat Model for Joint Communication and Sensing (JCAS) • Resilient Positioning, Navigation, and Timing (PNT) • Camera-based and wearable sensing technologies
Freedom from social risks	<ul style="list-style-type: none"> • Secure Data Sharing • Secure and Privacy-Enhanced Machine Learning • Trusted Execution Environment (TEE) • Remote Attestation (RA) • Multi-domain / Multi-cloud Federation • 3rd Party Facing Services • Cryptographic Agility • Decentralized Identity Management (DID)
Access to basic needs and a reliable social security system	<ul style="list-style-type: none"> • Network Migration • Multi-Radio Spectrum Sharing (MRSS) • Network of Networks • Multi-cloud Management Mechanisms • Subnetworks Architecture • Integration Fabric • Zero-Touch Closed Loop Governance and Intent-Based Management • Low Latency Scheduling Based on UE Traffic Patterns • Multi-Layer Downlink Radio Resource Control • Energy-Efficient Massive MIMO • Open RAN with Service Exposure • 6G Satellite Integration
The perception of safety and feeling secure in daily life	<ul style="list-style-type: none"> • Secure Workload Provisioning • Homomorphic Encryption • Quantum-Safe Cryptography • Zero-Touch Closed Loop Governance • Real-Time Zero-Touch Control Loops Automation and Coordination System • Management Capabilities Exposure Framework • Physical Layer Deception • Use of Synthetic Data • Intent-Based Management (Zero-Touch) • Human-Centric HMI (Human-Machine Interfaces)

6. Key Value Indicators (KVs)

Grounding Framework

What frameworks does the literature provide to support which KVs matter for your objective/stakeholder/decision combination? What elements do your stakeholders say need to be covered? *For this exemplar document, see key value, objectives, and references. Were there to be a specific use of this for a project, it is expected that additional research would be done to explain why each indicator was chosen, or how the selected indicators, as a group, are interrelated to the broader project goals. See the inclusivity sheet for a partial example.*

KVI Formulation

Exemplar KVIs: These are not intended to be standards or to be used by all projects or necessarily ones that actually get used. These exemplars offer ideal qualities that can be imitated to develop good KVIs. Each is presented as a stakeholder/objective/decision pairing (e.g. what stakeholder is being considered or who might use it, and the objective within the value) to help narrow the focus.

KVI	Stakeholder Impacted	Objective Aimed At	Decision it Supports
Decrease in communication outages during disaster events, measured by network coverage and speed of new connectivity establishment (example from 5G-Stardust, ECO-eNET)	Emergency Response Teams, Vulnerable Groups, Tech Developers	Protection from environmental hazards and risks	How to balance commercial traffic with emergency traffic, how to best manage combining alternative services. (Dimension 1)
Rationale: A failure in service during a disaster is a failure of the safety net.			

KVI	Stakeholder Impacted	Objective Aimed At	Decision it Supports
Stakeholder perception of personal safety resulting from solution use in trials (example from FIDAL, 6G-Path) Traffic accident rate reduction, assessed via expert evaluation, subjective feedback from trials (example from TARGET-X)	Individuals/Citizens, Communities, Vulnerable Groups	The perception of safety and feeling secure in daily life	Decide if they think a system is acceptable; Decide if they should trust a system. (Dimension 2)
Rationale: This combination balances statistical probability with safety perceptions, a combination shown to be more accurate than either individually, balancing what is technically possible with the need to ensure psychological safety.			

KVI	Stakeholder Impacted	Objective Aimed At	Decision it Supports
Measures the speed of response to critical events, as measured in trials, compared to baseline (example from ENVELOPE) % of actions taken with a device (before vs after) that suggest decreased risk taken by first responders/workers (example from ADROIT6G).	Workers, Businesses	Protection from environmental hazards and risks	Managers can decide whether to remove physical barriers in favor of virtual safety zones, or if a system is reliable enough to improve their working environments. (Dimension 3)
Rationale: A worker's physical integrity is directly tied to the system's ability to stop a machine before a collision or know when an incident has happened in order to be able to respond.			

KVI	Stakeholder Impacted	Objective Aimed At	Decision it Supports
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<p>Affordability of Access: The percentage of individuals reporting an inability to use the service because they cannot afford it [14].</p> <p>Digital Literacy Gaps: The disparity in digital skills across different age groups, educational levels, and geographical locations [14].</p>	<p>Vulnerable groups, Government/ Policymaker</p>	<p>Access to basic needs and a reliable social security system</p>	<p>Governments can decide if the cost of the new 6Gs solution is worth the benefits or if new policy might be needed. Vulnerable groups, in collaboration with technology developers, can establish the training and cost needs.</p> <p>(Dimension 4)</p>
<p>Rationale: Safety includes protection from social risks and economic security. If a citizen cannot afford 6G, they cannot access the 6G-enabled social safety nets or emergency services, making them fundamentally unsafe.</p>			

KVI	Stakeholder Impacted	Objective Aimed At	Decision it Supports
<p>The percentage of essential public services (healthcare, education, social assistance) that are able to be migrated to the proposed 6G-enabled network in the next 2 years [14].</p>	<p>Individuals, Emergency Response Teams, Government</p>	<p>Access to basic needs and a reliable social security system</p>	<p>Assessing if service design needs to be more adaptable to different circumstances.</p> <p>(Dimension 5)</p>
<p>Rationale: If 90% of healthcare is on 6G but the network is prone to outages, the population feels <i>less</i> safe. This indicator forces projects to prove that the 6G network is robust and resilient enough to do the job. Tracking the migration rate tells you how effectively you are removing the barriers to care.</p>			

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Quality of Life in and by 6G

1. Key Value Definition

Pillar: Societal

KV: Quality of Life

Explanation of KV: Quality of Life and well-being are deeply interconnected concepts that operate at multiple levels. Quality of Life assesses an individual's position relative to their broad social and cultural environment, while well-being provides a more focused measure of their subjective cognitive and emotional state. It includes economic prosperity, health, as well as a subjective sense of well-being and fulfilment shaped by individual experiences, cultural values, and personal aspirations [1] [2] [3]. Involves various dimensions such as income, housing, health, education, strong relationships, leisure, quality of surrounding environment, and enriching cultural experiences.

Well-being consists of two distinct but correlated components: life satisfaction (a long-term cognitive evaluation) and happiness (a more immediate emotional state) [4] [5]. Together, these create a multi-level framework based on complex interplay between individual, societal, and systemic drivers [2] [3]. Quality of life is determined not by wealth alone, but by how society supports its citizens through various forms of capital—human, social, economic, and planetary [4] [6] [7]. These elements are important to consider together because studies show how they manifest and what is prioritized among them can change even across Europe [8] [2].

It is about using technology, innovation, and social systems to make everyday life easier, more accessible, more resource-conscious in ways that supports long-term environmental, social, and economic well-being. This can include making public services more accessible to underserved populations, improving food production and access, improved water management, better transportation systems, or the opportunity for more flexible work environments. It also relates to the physical and emotional consequences of the emotional consequences of living in a constantly connected system. It also highlights the importance of social interactions and belonging.

2. Sub-Objectives

These sub-objectives outline specific areas where 6G can contribute to well-being.

- **Physical and Mental Health:** Core individual well-being includes physical health, psychological state, social relationships, personal environment, and spirituality [1] [9]. Elements like energy levels, self-esteem, capacity for work, personal relationships, and access to quality healthcare form the foundation of individual well-being.
- **Independence and Mobility:** A critical feature is a person's capacity to perform daily living activities and their ability to work [1]. Monitoring should focus on whether innovations or social changes enhance or restrict individual mobility and autonomous functioning.
- **Agency and Control:** Individuals must feel their life is steered by personal decisions rather than external fate [2] [10]. A shift toward external locus of control signals that systems (technological or political) are becoming too intrusive or disempowering.
- **Economic prosperity:** The generosity and accessibility of social programs directly impact well-being [7]. Tracking availability of quality healthcare, financial resources, and universal social protections ensures necessary economic capital remains intact [11].
- **Social Cohesion:** social cohesion has a significant positive effect on well-being and acts as a moderator, reducing the relative importance of income in determining life satisfaction [12]. Well-being elicits civic-mindedness, meaning that satisfied individuals are more likely to operate in a cooperative and trustful manner for the common good [13].

- **Environmental and Home Quality:** Physical safety, quality home environments, and access to clean green spaces are prerequisites for stability [14] [11]. Protection of these is essential, as unsafe or polluted living environments diminish subjective well-being regardless of income. Conversely, higher levels of life satisfaction predispose individuals to adopt environmentally responsible behaviours [13].
- **Work-Life Balance:** Working conditions matter, specifically predictable hours and degree of autonomy over professional tasks [2] [15]. Encroachments on personal time or reduced workplace agency are leading indicators of declining human capital and life satisfaction [16] [17].
- **Leisure and enriching cultural experiences:** A person's capacity, opportunity, and inclination to participate in relaxation and pastimes, including physical activities, social activities, home-based entertainment [1]. Cultural diversity, freedom, and modernity all facilitate happiness [3].
- **Personal fulfilment:** Empower individuals to pursue their goals, express their creativity, continue to learn, problem-solve and live more fulfilling lives. This is a core component of long-term well-being, driven by both psychological factors and external structures [2] [18].

In addition, these are considered a sub-objective of well-being or a key value in itself, depending on the perspective taken:

- **Digital Inclusion and Service Accessibility:** The ability to access essential services remotely (such as eHealth records or telework opportunities) increasingly impacts quality of life [19] [15]. Ensuring digital equity prevents technological shifts from creating gaps in social capital for underserved communities [15].
- **Institutional and Interpersonal Trust:** Trust serves as the primary buffer against socio-economic stress [14]. While income accounts for about two-thirds of variance in life satisfaction, trust accounts for one-third and significantly dampens the negative impact of low income [12]. While Europeans are united in diversity, significant tensions exist between different generations and educational levels regarding their feeling of closeness to Europe and trust in institutions [3]. This could be considered either a sub-objective here, or a key interlinked value of its own.

Relevance to 6G: 6G has the potential to significantly enhance quality of life across various dimensions. For example, 6G's high speed and low latency can enable new applications in telemedicine, smart cities, and virtual reality, which can improve healthcare, create more liveable urban environments, and enrich entertainment, cultural, and community experiences. However, these benefits should be distributed equitably. Potential negative impacts, such as increased inequality or social isolation, should be mitigated.

3. Stakeholders and Pain Points (What's at stake for who?)

Stakeholder	Their potential pain-points the KV could help illuminate
Individuals (citizens, patients, consumers)	Job Insecurity and Disruption, Intrusive monitoring, psychological strain, lack of educational opportunities, social isolation, difficulties in accessing essential services and healthcare, barriers to personal fulfilment.
Communities (urban and rural)	Infrastructure gaps and digital divide, imbalanced regional development, social disparities, environmental challenges, limited opportunities for cultural enrichment.
Healthcare providers	Integration and connectivity hurdles, Challenges in delivering quality care to remote areas, difficulties in managing patient data, the rising cost of healthcare, cybersecurity risks, technological complexity.
Educational institutions	Difficulties in providing personalized and accessible education, the digital divide, the need to adapt to new technologies, early age personal and social anxiety.

Businesses (various sectors)	Need to adapt to changing consumer demands, new forms of competitive pressures, blurred work-life boundaries, skill shortages
Governments and public sector	Challenges in addressing social inequalities, providing efficient public services, promoting economic development, political instability, inadequate social protection.
Entertainment and cultural organizations	Difficulty in reaching wider audiences, challenges in creating engaging and interactive experiences, the need to preserve cultural heritage in the digital age, asset inequality.

4. Impact

How Can Stakeholders Benefit (from engaging this value)?

Stakeholder	Positive and Negative Impacts
Individuals	Improved health and well-being, greater access to education and economic opportunities, stronger social connections, enhanced personal fulfilment. Negative impact: Exacerbation of existing inequalities, with some groups benefiting more than others; increased social isolation and digital divide for those who lack access to or skills to use 6G technologies. Mental health impacts from constant connectivity.
Communities	More liveable and sustainable environments, improved access to services and resources, greater social inclusion, and enhanced cultural vibrancy. Negative impact: Exacerbation of existing inequalities, with some groups benefiting more than others, lack of funds for access. Health services where the technology substitutes for the human, isolation.
Healthcare providers	More efficient and effective healthcare delivery, improved patient outcomes, and reduced healthcare costs. Negative impact: increased need for care for the public due to mental health issues, increased stress or sedentary lifestyles. Health services where the technology substitutes the for human, isolation.
Educational institutions	Enhanced learning experiences, greater accessibility to education, and improved student outcomes. Negative Impact: increased dependence on technology, leading to a decline in critical thinking and problem-solving skills.
Businesses	New market opportunities, increased productivity and innovation, and enhanced competitiveness. Negative Impact: always on culture, workplace surveillance, data extraction, planned obsolescence.
Governments and the public sector	Improved public services, greater citizen engagement, and more sustainable economic and social development. Negative Impact: expansion of surveillance, algorithms without governance, vendor lock-in, loss of privacy in public spaces, overreliance on data-based technologies for public services, civic disengagement.
Entertainment and cultural organizations	Wider reach, more engaging and interactive experiences, and new avenues for cultural preservation and expression. Negative impact: Loss of cultural heritage and homogenization of cultural experiences.

What Actions or Decisions Will Result?

e.g. who makes decisions around this objective? What kind of decisions?

Stakeholder	Who would use the results of assessments within this value frame? How?
Individuals (citizens, patients, consumers)	Can decide how they want 6G to fit into their daily lives, such as proactively manage their health using 6G-enabled tools, embrace flexible work environments, utilise immersive learning platforms, or decide to use smart community services.
Communities (urban and rural)	Can strategically invest in 6G-powered smart infrastructure to enhance liveability and sustainability. Can decide how to prioritise initiatives that bridge social and digital divides to ensure equitable access and foster cultural vibrancy.
Healthcare providers	Can decide to include telemedicine, remote diagnostics and surgical assistance to reach underserved areas, and use advanced data analytics to personalize care, optimize resources, and boost efficiency.
Educational institutions	Can decide on the best ways to integrate 6G-powered immersive technologies for personalized and accessible learning and invest in lifelong learning platforms to bridge the knowledge divide.
Businesses (various sectors)	Can better address consumer demands, unlock new business models, identify what harms might arise from new technologies on the market, identify ways to best support underserved communities.
Governments and public sector	Can decide how best to fund 6G infrastructure for underserved areas, boost access and economies, and implement data-driven urban planning and public safety with 6G for social cohesion and sustainable development. Can understand controversies that they need to act on.
Entertainment and cultural organizations	Can decide how to leverage 6G for interactive cultural experiences and innovative preservation projects, expanding reach and fostering new artistic expression.

5. Implications for Technology and Use Case/PoC

Use Cases/PoCs

Objective	How might it affect use cases?
Physical and Mental Health	<p>6G must transition from simple data access to proactive well-being monitoring and humanization of care. It could enable real-time tracking of parameters like stress, mood, and fatigue to ensure safety. Use cases should avoid exacerbating the age of loneliness or social anxiety caused by excessive screen time.</p> <p>Key Question: Does this design improve protecting the user from mental and physical strain or social isolation?</p>
Independence and Mobility	<p>6G should be treated as multi-purpose platform, allowing the elderly or those with chronic illnesses to live independently through remote monitoring and autonomous transport. Focus not just on what the tech can do, but on the impacts of the life ability of the person, such as their capacity to perform daily living activities regardless of physical location.</p> <p>Key Question: Does the use case enhance functional autonomy for vulnerable groups in remote or rural areas?</p>

Agency Control	and	<p>Systems should move to avoid black box logic where algorithms or technology decides for humans. Incorporate human-in-the-loop frameworks that supports rather than replaces human decision-making.</p> <p>Key Question: Does this technology empower the individuals to be in control, or does it lead to intrusive monitoring?</p>
Economic prosperity		<p>Services should drive community wealth building, ensuring economic benefits are anchored locally rather than just for shareholders/industry. Distinguish between absolute growth and inclusive growth.</p> <p>Key Question: Does this service contribute to decent work and a living wage, or does it risk job polarisation and displacement?</p>
Social Cohesion		<p>Use cases must mitigate social fractures and prevent the creation of second-class citizens who are excluded from the digital fabric. Use cases should facilitate spontaneous, natural social interactions across distances, strengthen community resilience through shared digital spaces, and enable new forms of collaborative problem-solving that bridge geographical or social gaps.</p> <p>Key Question: Does this use case foster a sense of belonging or mattering or does it deepen societal polarisation?</p>
Environmental and Home Quality		<p>Uses cases can focus on environmental stewardship and monitoring, focusing on creating sensors, data, and related systems (house, city, environment) that users can directly employ to make key planning decisions, experts can use to make models for urban planning, environmental resilience, or transport, etc, that meet both environmental and human needs. Provide data that supports green procurement needs.</p> <p>Key Question: How can 6G-enabled monitoring improve the physical safety, resource efficiency, and overall liveability of the home environment?</p>
Work-Life Balance		<p>Uses cases could focus on digital boundaries, supporting the right to disconnect, improved worker control or employee autonomy. They could also balance this by focusing on issues of social isolation, engaging different kinds of tools that balance autonomy with interaction.</p> <p>Key Question: Does this technology encourage a constant-on culture, or does it provide the user with the agency to shut down work-related data flows?</p>
Leisure enriching cultural experiences	and	<p>Use cases could foster partnerships between public, academic, cultural heritage, and industrial institutions, new forms of tourism and entertainment that protect local places, support long term growth instead of short-term entertainment.</p> <p>Key Question: How does the technology support long-term flourishing through immersive and active cultural participation?</p>
Personal fulfilment		<p>Use cases could have an overall focus on meaningful social interactions, creativity, and problem-solving, shifting away from short term happiness. They should focus on being human enablers rather than replacements of human agency.</p> <p>Key Question: Does the technology help individuals reach their full potential?</p>

Technology

What technologies are implicated most in this value? What tech features or enablers may reflect or even reinforce this problem?

This list in the following table is not complete, but an initial derivation from the enablers listed in discussion with the KVs based on what is being done currently in projects. It is expected to be expanded and refined, as a living resource.

Objective	What technology could be enablers?
Physical and Mental Health	<ul style="list-style-type: none"> Enhancing Joint Communication and Sensing (JCAS) Capabilities Sustainable AI/ML-based Control IoT-driven Monitoring (e.g. Wearable sensors) Real-time Zero-touch Control Loops Automation and Coordination System Human-machine Intent Interface Design Assistive Technology (e.g. Occupational exoskeletons)
Independence and Mobility	<ul style="list-style-type: none"> Autonomous Mobility (CCAM): UAV Corridors: UAV-enabled networks Reliable Coverage: Non-Terrestrial Networks (NTN)
Agency and Control	<ul style="list-style-type: none"> User-Centric Trust Management: Network Security Machine Learning Operations that support human-in-the-loop AI Transparency and Auditability Privacy-aware data management frameworks Distributed AI agents
Economic prosperity	<ul style="list-style-type: none"> AI-as-a-Service (AlaaS) Machine Learning Operations (MLOps) Cloud Transformation in 6G-quantum Architecture Real-time Zero-touch Control Loops Automation and Coordination System Multi-vendor Automation and Management Intent-Based Orchestration and Lifecycle Management Cost of Ownership Cell-free massive MIMO AI-driven resource orchestration
Social Cohesion	<ul style="list-style-type: none"> Human-machine Intent Interface Design Holographic telepresence Enhancing Joint Communication and Sensing (JCAS) Capabilities AI Transparency and Auditability Intent Translation and Provisioning Shared Digital Environments/Real-time Digital Twins
Environmental and Home Quality	<ul style="list-style-type: none"> Smart Grids/6G-enabled grid balancing Smart Home Sensors/Energy-neutral sensors Environmental Monitoring Sensing-aided connectivity
Work-Life Integration	<ul style="list-style-type: none"> Ubiquitous connectivity (e.g. via TN/NTN convergence) AR-driven remote support
Leisure and enriching cultural experiences	<ul style="list-style-type: none"> Enhancing Joint Communication and Sensing (JCAS) Capabilities Sustainable AI/ML-based Control AI-as-a-Service (AlaaS) Machine Learning Operations (MLOps) Human-machine Intent Interface Design XR/AR/holographic experiences
Personal fulfilment	<ul style="list-style-type: none"> Monitoring and Telemetry Framework AI-enabled edge services XR/AR-based learning technology Human-machine Intent Interface Design

6. Key Value Indicators (KVI)s

Grounding Framework

What frameworks does the literature provide to support which KVI's matter for your objective/stakeholder/decision combination? What elements do your stakeholders say need to be covered? (For this exemplar document, see key value, objectives, and references. Were

there to be a specific use of this for a project, it is expected that additional research would be done to explain why each indicator was chosen, or how the selected indicators, as a group, are interrelated to the broader project goals. See the inclusivity sheet for a partial example.)

KVI Formulation

Exemplar KVIs: These are not intended to be standards or to be used by all projects or necessarily ones that actually get used. These exemplars offer ideal qualities that can be imitated to develop good KVIs. Each is presented as a stakeholder/objective/decision pairing (e.g. what stakeholder is being considered or who might use it, and the objective within the value) to help narrow the focus.

KVI	Stakeholder Impacted	Objective Aimed At	Decision it Supports
<p>Intuitive, user-friendly systems and services that reduce complexity, enhance usability, and improve accessibility for all users, measured by Network Safe Actions Auto Ratio (example from Safe-6G).</p> <p>Continuous, high-fidelity monitoring via in-body or wearable medical sensors, aims at early detection and personalized care solutions (example from AMBIENT-6G)</p>	Business (e.g. industry R&D teams)	Service Availability, Agency and Control, Physical and Mental Health	Assess if the technical speeds and data are translating into a satisfying human experience, or actionable information. (Dimension 1)
<p>Rationale: Low quality, complex, and unreliable tools add to stress, add to mental strain, and decrease agency. Early detection equally supports anticipation of harm, and thus allows actions to take place before they are most critical.</p>			

KVI	Stakeholder Impacted	Objective Aimed At	Decision it Supports
<p>Reduction in caregiver stress, via continuous monitoring to show reduced anxiety and improved response to emergencies, in trials (Example from 6G-Path)</p> <p>Perception of enhanced autonomy for elderly, women, children and in general, via survey (example from HEXA-X-II).</p> <p>The ability of users (e.g., PPDR personnel) to use tools while keeping a focus on the final goals (saving lives and preventing harms) (example from FIDAL)</p>	Healthcare providers, technology developers	Agency and Control, Physical and Mental Health	Learn where breaking points are in health care chains and identify if the technology is actually easing those points. Is more training needed or does the technology need different features. (Dimension 2)
<p>Rationale: Reducing strain is a direct improvement to a worker's long-term health. Being able to do one's main activity without being hindered by technology fosters a sense of empowerment.</p>			

KVI	Stakeholder Impacted	Objective Aimed At	Decision it Supports
<p>Number of prevented traffic accidents, simulated or assessed by expert (from Target-X, ENVELOPE, VERGE)</p> <p>Reduced patient travel enabled by precision healthcare and telepresence, simulated (example from Hexa-X-II)</p>	Healthcare providers	Physical and Mental Health, work-Life Balance	Learn if a system increased their capacity and what kinds of investments are needed to see results. (Dimension 3)

Rationale: Preventing accidents removes the physical and mental strain of high-risk work environments. Travel affects a person's and community's time and energy, especially for those in more vulnerable situations. Together both demonstrate a reduced burden of care.

KVI	Stakeholder Impacted	Objective Aimed At	Decision it Supports
<p>Citizen and Expert Panel to allow residents to evaluate technology adoption and distributions strategies directly [20].</p> <p>Trust in public institutions, as assessed via survey of stakeholders after explanation of how a service would use the new technology [14].</p>	Government & public sector, Communities	Service Availability, Trust	<p>To address communication activities around a technology, to identify if external oversight is needed to foster trust, to request increased transparency.</p> <p>(Dimension 4)</p>
<p>Rationale: These indicators involve direct democratic oversight, where residents and specialists deliberate on how a technology should be rolled out.</p>			

KVI	Stakeholder Impacted	Objective Aimed At	Decision it Supports
<p>Select Social Progress Index (SPI) indicators that support assessing the readiness of society to benefit from the technology [21] [22].</p> <p>Equity-Adjusted Net Health/Economic Benefit via, distributional Cost-Effectiveness Analysis [23] [11].</p>	Businesses, Government	Economic prosperity, Institutional Trust, Social Cohesion	<p>Deciding where to fund, subsidize, or tax broadband or training centres before deploying new technology</p> <p>Determining how much upskilling is needed before the tech can be safely used.</p> <p>(Dimension 5)</p>
<p>Rationale: One measures societal readiness (the context the technology enters), and the other measures equitable outcomes (the actual impact of the technology). Combined they help assess how the technology might be able to support social growth as well as the elements in society that might need to shift to encourage that growth.</p>			

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Building Knowledge and Skills via 6G

1. Key Value Definition

Pillar: Societal

KV: Building Knowledge and Skills

Explanation of KV:

Building knowledge and skills is a cornerstone of European social policy, representing a fundamental commitment to human capital as the driver of a prosperous, fair, and resilient society. It is key to a beneficial 6G-enabled economy.

This value is defined as the process of equipping individuals with the understanding, competencies, values, and attitudes necessary to foster economic competitiveness, social solidarity, and active democratic participation. This principle is formally enshrined within the European Pillar of Social Rights and the European Skills Agenda, which explicitly prioritises general education, professional training, and lifelong learning as essential rights for all citizens. This includes a workforce adept at leveraging new, including 6G, technologies to drive economic and social stability [1]. It also includes citizens that possess the digital literacy, general skills, and resilience to transform disruptive technologies into tools for personal and collective advancement and equip vulnerable groups to meet their own social needs [2] [3] [4].

This foundation extends far beyond mere technical proficiency. Rather, this includes four interdependent dimensions: technical, aesthetics (e.g. creativity), ethical (e.g. responsibility) and political (e.g. citizenship and democracy) [4]. It encompasses a proactive approach to cultivating the competencies necessary for technological innovation, especially that around 6G, including technical skills like cybersecurity but also soft skills like critical thinking, creativity, and complex problem-solving [1]. Developing these skills is essential for individuals to understand how knowledge is produced, how insights are shared across diverse teams or with diverse publics, and how innovation occurs, particularly important as 6G incorporates emergent technologies like AI [5]. By empowering citizens with these competencies, they can become active co-creators of a future that is both sustainable and equitable, capable of navigating complexity and contributing meaningfully to societal progress.

2. Sub-Objectives

- **Promoting digital literacy and skills among all citizens:** This is foundational knowledge and competencies, motivation, and resilience required for individuals to actively generate social value from 6G. Without it, individuals cannot access essential online services, engage in the 6G-enabled digital economy, make well-informed decisions on the use of 6G-enabled products/services towards their wellbeing, or understand how knowledge is produced and shared in the digital age [2] [3] [6]. Nor can they contribute to or inform the shape of 6G innovation. It is more than a technical checklist [7].
- **Empower people to make informed decisions in digital contexts.** A spectrum of 6G skills required for effective civic participation [8]. Education and media literacy focused on critical thinking and ethical awareness shapes active citizens capable of participating in public debate, combating disinformation, and to make informed decisions to improve their well-being [9].
- **Developing a skilled workforce:** A skilled workforce is the direct output of effective knowledge and skill building. Successful 6G innovation and implementation requires multi-disciplinary teams that cover competencies beyond pure technical expertise, such as ethics, data science, and public communication [10]. Such diverse and complementary skills ensure there are individuals capable of creating, applying, and benefiting from 6G. Workforces will need skills in electronic engineering and software engineering [11], as well as socio-technical skills, such as empathy and social responsibility [7]. Upskilling as a vital

non-technical enabler, particularly around communication and engagement with the public [12] [13]. This potentially requires revamped academic curricula and industry-academia partnerships to bridge existing gaps, as well as continuous learning [1].

- **Fostering innovation and creativity:** For 6G to create (or support) new innovative services, new forms of collaboration between disciplines will be needed to improve long term innovation and impact [14]. Innovation and creativity are engines of new knowledge production, research, and insight generation, and are fundamental for the use of 6G technologies to foster prosperity and competitiveness. As automation, multi-sensory experiences, and AI become more deeply integrated into 6G, human-centric skills such as creativity and emotional intelligence will become invaluable [1]. The necessary knowledge sharing for this requires a culture of trust and alignment of values between partners [15].

Relevance to 6G: The successful development and deployment of 6G will depend heavily on the availability of a skilled workforce and a digitally literate population. Without adequate investment in education and training, there is a risk that the potential benefits of 6G will not be fully realized, and that existing inequalities will be exacerbated. The SNS JU emphasizes the need for advanced skills in areas such as AI, cybersecurity, and network management to support the deployment of 6G.

3. Stakeholders and Pain Points (What's at stake for who?)

Stakeholder	Their potential pain-points the KV could help illuminate
Citizens	Lack of relevant skills and motivation for 6G-related jobs; difficulty in adapting to new technologies/fear of overload; exclusion from the digital economy due to lack of digital literacy; lack of understanding of 6G in order to shape industry choices; lack of educational resources to become active citizens; fear of stigma for needing support in using digital tools.
Engineers/6G technologists	Disciplinary and work force silos, lack of funding or structure to support the essential cross-disciplinary outreach and public engagement needed for technology acceptance.
Educational institutions	Difficulty in updating curricula to keep pace with technological advancements, lack of resources to provide adequate training, challenges in reaching diverse learners. Limited capacity to provide digital literacy training, difficulty in reaching marginalized communities. Constant need to upskills educators to keep up with 6G innovation, finding and retaining qualified staff.
Businesses	Shortage of qualified workers, difficulty in finding employees with the necessary skills, need to invest in employee training and development, uncertain or low return on investment.
Governments and public sector	Challenges in developing effective education and training policies, need to invest in infrastructure and resources, difficulty in measuring the impact of training programs, developing knowledge standards in a multi-disciplinary space, regulation is often behind the technology, finding the funds to support digital mandates. The need for improved local skills to support digital sovereignty.
Research Organisations	Lack of funding for long-term research, difficulty in accessing relevant data and resources, challenges in translating research findings into practical applications, and the need to collaborate across disciplines and institutions.

4. Impact

How Can Stakeholders Benefit (from engaging this value)?

Positive impacts are the benefits experienced if the potential of 6G is engaged or 6G is able to be used to its fullest. Negative impacts are the opposite: what happens if the potential of 6G is not reached? Or, e.g. what happens if too much priority is given to technology skills at the expense of soft skills or the motivational dimensions of learning?

Stakeholder	Positive and Negative Impacts
Citizens	Enhanced employability, increased earning potential, greater ability to participate in the digital economy or meet one's own social needs, improved quality of life, independence, and ability for civic engagement. Negative impacts: widening skills gap with reduced earnings and career prospects, individuals lacking the necessary expertise to participate in a 6G-enabled economy, chronic cognitive overload and anxiety.
Engineers/6G technologists	New career opportunities, leading a digital revolution, becoming an essential knowledge worker, ability to merge technical skills with human creativity. Negative impact: new ethical accountabilities, new public responsibilities, constant threat of skill obsolescence and demand for continuous learning, increasingly complex working environments.
Educational institutions	Increased reach, relevance, and cutting-edge nature of their programs, increased ability to engage cross-domain research and education, improved student outcomes, and enhanced reputation. Negative impact: finding and retaining qualified staff, increased costs for cross-disciplinary activities, new educational models required.
Businesses	Competitive advantage, access to a larger pool of qualified workers, increased productivity and innovation, and enhanced competitiveness. Negative impact: Increased unemployment and social exclusion for those without digital literacy, increased staff education burdens and costs, increased operational complexity.
Governments and public sector	A more skilled and adaptable workforce, tools to bridge digital divides, increased economic growth, reduced social inequality. Negative impact: regulatory lag, tensions between national initiatives and local priorities. Failure to build skills creates a sovereignty risk.
Research Organisations	Increased funding opportunities, access to cutting-edge resources and data, enhanced collaboration across disciplines and institutions, and greater impact of their research findings on real-world applications. Negative impact: increased cost, increased public communication needs, increased need for physical infrastructure to support knowledge.

What Actions or Decisions Will Result?

e.g. who makes decisions around this objective? What kind of decisions?

Stakeholder	Who would use the results of assessments within this value frame? How?
Citizens	To make informed decisions about their education and career paths, and to identify opportunities for lifelong learning. To better assess if a technology will provide them benefits.
Engineers/6G technologists	To make informed decisions about when to offer public trainings or when to seek their own job training, when to shift design due to specific literacy capabilities of stakeholders, better assess how to reduce mental fatigue for 6G users, how to engage the practicalities of human-in-the-loop.
Educational institutions	To design curricula and training programs that align with the skills needs of the 6G era.
Businesses	To inform their hiring and training strategies, and to identify areas where investment in employee development is needed.
Governments and public sector	To develop policies that promote digital literacy, support workforce development, and ensure equitable access to education and training. To prioritize projects that promote skills development and address the digital divide.
Research Organisations	To identify key knowledge gaps, prioritize research areas, and secure funding for projects that advance 6G-related knowledge and skills. To evaluate the impact of their research and communicate their findings to broader audiences, including policymakers, industry stakeholders, and the general public.

5. Implications for Technology and Use Case/PoC

Use Cases/PoCs

Objective	How might it affect use cases?
Promoting digital literacy and skills among all citizens	<p>Recognizes that simply having access is not enough; use cases must actively facilitate the development of meaningful digital competencies across diverse demographics, addressing barriers like confidence, relevance, and language, particularly where digital literacy is limited. Use cases could focus on how they can improve learning opportunities for marginalised communities.</p> <p><i>Key Question: How can training and education in 6G or via 6G improve the impact and reach of 6G technologies?</i></p>
Empower people to make informed decisions in digital contexts	<p>Goes beyond mere benefits of connectivity to address how knowledge about 6G actively can impact 6G deserts or be catalyst for a more just society.</p> <p><i>Key Question: How can training and skills in 6G or via 6G empower people to make their lives better?</i></p>
Developing a skilled workforce	<p>Focus on how 6G actively facilitates the acquisition and application of complex skills by workers, making learning more effective, accessible, and responsive to individual needs and industry shifts. They could emphasize engagement, practical experience, and adaptability. They could focus on identifying the future skills and knowledge needed to ensure benefits and mitigate harms.</p> <p><i>Key Questions: How can 6G technologies improve training and education for workers and workplaces? What kind of training or education improves the benefits 6G technologies can offer workers and workplaces?</i></p>
Fostering innovation and creativity	<p>How 6G can directly augment human cognitive processes, collaboration, and experimentation, lowering barriers to entry for creative endeavours and innovative problem-solving for a wider range of individuals. How leveraging human-centric skills (e.g. creativity, emotional intelligence) improves 6G impacts. Use cases could be prioritised that have a potential for social return on investment, rather than just profit or cost.</p> <p><i>Key Question: What kinds of training and skills in 6G or via 6G can support augmenting human ingenuity and broaden access to innovation?</i></p>

Technology

What technologies are implicated most in this value? What tech features or enablers may reflect or even reinforce this problem?

Objective	Technology Enabler
Promoting digital literacy and skills among all citizens	<ul style="list-style-type: none"> Extended Reality (XR), to engage engagement and skill development. Augmented Reality (XR), to increase educational opportunities Non-Terrestrial Networks (NTN), to ensure that students in remote regions can access virtual classrooms and labs Integrated Sensing and Communication (ISAC) to allow students to observe events remotely Virtual Base Stations, to provide immersive training environments

	<ul style="list-style-type: none"> • AI-as-a-Service (AlaaS) • Machine Learning Operations • Programmable Network Monitoring and Telemetry
Empower people to make informed decisions in digital contexts	<ul style="list-style-type: none"> • AI/Al-as-a-Service (AlaaS), that provides high-level explanations for the network's automated decision or real-time views of network activity/footprint in ways that supports decision-making. • Network Observability to allow stakeholders to make informed decisions about resource management
Developing a skilled workforce	<ul style="list-style-type: none"> • Immersive video, to simulate different working scenarios • Haptic Sensing, to raise the quality of training by incorporating the sense of touch. • AR and XR, to train with remote expert supervision • Programmable logic controller, networking monitoring, and telemetry functions to the edge, to allow Industry 4.0 workers to train on flexible systems. • Synergetic Orchestration Mechanisms for the Computing Continuum • Closed loop coordination for intent management • Intent-Based Orchestration and Lifecycle Management
Fostering innovation and creativity	<ul style="list-style-type: none"> • Mixed Reality platforms, to enable stakeholders from different locations interact together. • Network as Code and Developer Portals to allow developers without expertise to create novel applications • Machine Learning Operations • Network Digital Twins Creation Mechanisms

Some enablers are included could also negatively affect the value/objective in question. While these enablers do not inherently block skill development, without human-in-the-loop options, documentation, and training interfaces, they risk deskilling the workforce and shifting expertise to only a few system designers.

6. Key Value Indicators (KVIs)

Grounding Framework

What frameworks does the literature provide to support which KVIs matter for your objective/stakeholder/decision combination? What elements do your stakeholders say need to be covered? *For this exemplar document, see key value, objectives, and references. Were there to be a specific use of this for a project, it is expected that additional research would be done to explain why each indicator was chosen, or how the selected indicators, as a group, are interrelated to the broader project goals. See the inclusivity sheet for a partial example.*

KVI Formulation

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KVI	Stakeholder Impacted	Objective Aimed At	Decision it Supports
Accuracy and effectiveness of real-time language understanding and translation capabilities (example from 6G-Cloud) Increased number of educational products available as immersive services (example from ENVELOPE)	Engineers/6G technologists	Promoting digital literacy and skills among all citizens	Is the technology sufficient to meet a use case? (Dimension 1)

Rationale: Technologically, the quality, effectiveness, and number of tools out there for diverse audiences to use that are of high quality has the potential to enable improved learning and skills. While alone it is insufficient to make a claim about improved skills, it can be a foundational element.

KVI	Stakeholder Impacted	Objective Aimed At	Decision it Supports
Perceived usefulness for teaching and learning experience (example from 6G-Path, TrialsNET) Perceived quality of virtual services for education (example from VERGE)	Citizen	Developing a skilled workforce	Decide if they want to invest in the new technology to improve their education. (Dimension 2)
Rationale: If the citizen perceives the learning experience as significantly better than traditional methods, they will more likely decide to invest resources in it, rather than stick with good enough previous tools.			

KVI	Stakeholder Impacted	Objective Aimed At	Decision it Supports
Increased availability of quality education resources (example from 6G-Senses) Predicted adoption rate of educational programs made available via the 6G service (example from HEXA-X-II)	Research Organisations	Fostering innovation and creativity	Decide how to redirect their budget, e.g. from network-based research to social-based research. (Dimension 3)
Rationale: Creativity requires soft skills not just technical skills. Understanding the potential uptake and availability of resources, as supported by 6G technologies, would allow research organisations to better assess how to shift their own programmes and funding to support real-world applications. For example, if the data shows that citizens want the technology, but social groups are not adopting it, the organization could decide to fund more social research to better understand the situation.			

KVI	Stakeholder Impacted	Objective Aimed At	Decision it Supports
The fit between current regional education provision and future knowledge and skill profiles required for the 6G technology in question [11]. The predicted number of 6G-enabled access points available per population in target areas [16].	Educational institutions	Promoting digital literacy and skills among all citizens	Whether to invest in traditional classrooms or mobile learning. How to partner with the wider region to share their network resources to balance skills and technology. (Dimension 4)
Rationale: Combining regional skill gap analysis with infrastructure density supports geospatial and redistributive decisions in such a way that enables a focus on how schools and universities can help prevent a new 6G digital divide.			

KVI	Stakeholder Impacted	Objective Aimed At	Decision it Supports
Price of connectivity compared to other commodities, like 1 kg of rice [16].	Governments and public sector	Empower people to make informed	Decide if they regulate or finance 6G like other educational support networks?

Local communities, after training, able to manage what are the most important applications for them, as assessed by local and external experts [17].		decisions in digital contexts	Decide on the national 6G education strategy. (Dimension 5)
Rationale: Affordability provides the opportunity to learn, while community self-management provides the evidence of agency. They provide the evidence needed for governments to decide between maintaining the status quo or investing in a transformative national 6G education strategy, and how centralised such management needs to be.			

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APPENDIX B – TEMPLATE GUIDE

Template: 6G Key Value Definition & KVI Articulation

General introduction

This template is designed to help define a core Key Value (KV) for 6G, analyse its societal and technological implications, and establish necessary indicators (KVIs).

Currently, KVI are defined in relation to PoC and Use Cases. As the SNS JU community gathers evidence about the effectiveness of the current diversity of KVIs, this represents a vital first step. Once strategic decisions are made around the lessons learned from the early definitions and applications of KVIs, a more overarching list of KVIs can be articulated for 6G in general.

Even fundamental research or low-TRL can contribute to societal or sustainability goals. The key is reframing the KVIs from an indicator of impact created to indicators of drivers of choices linked to intended impacts.

Start by considering where KVIs might eventually apply in your project. Could what you learn from the indicators influence technology design, policy recommendations, pilot choices, stakeholder engagement? Are you pursuing incremental changes or something transformational? Reflect on who/what might benefit or be affected (directly or indirectly), and what specific challenges your work addresses, such as improved individual health, decreased pollution, greater equity in 6G impact, better working conditions, greater community connection, or economic opportunities. Consider any strategic requirements from your funding.

As you do this exercise, don't jump straight to specific outcomes. Instead, map possible pathways from your project activities to the broader impact, e.g. what you can change within the project from technology design to who you consult. These pathways contain the insights needed to identify meaningful KVIs.

Before you begin, review policy, industry, or disciplinary roadmaps, and existing research. This will help reveal links between your research and wider challenges that are not immediately obvious. It could also provide pre-existing frameworks and indicators to draw upon. You could also draft a brief impact pathway or theory of change, which is a simple outline or diagram showing what you think are key steps needed for your work to contribute to broader outcomes. Having this documented would also support future systems mapping, essential for longer-term value and sustainability assessments.

The steps you'll be taken through:

The following steps guide you from defining your project's core value through to identifying how to measure its impact. You can complete the template linearly or iteratively, revisiting earlier steps as your thinking evolves. It does so by having you:

- Name and define a value
- Break it down into actionable objectives
- Articulate who's affected
- Describe impacts, positive and negative
- Connect value to technical work and use cases
- Identify grounding research
- Derive indicators fitting the previous points

This template is not a formula, nor does it resolve all open questions about KVIs. However, drawing on the challenges identified across the projects and guidance from external experts and literature, it establishes foundations that make defining KVIs easier. It also supports the work needed to find commonalities and harmonise approaches across the projects.

1. Key Value Definition

Clarify your understanding of the core value you are addressing. This establishes a shared language and goal for your project and with your stakeholders. It ensures that all subsequent objectives, indicators, and technical choices are aligned with a clearly defined societal, economic, or environmental benefit. In the long run, this should be pre-defined so you can simply select from a list deemed relevant for 6G.

Pillar	Identify the overarching Pillar: Societal, Economic, or Environmental.
Key Value (KV)	State the specific value, e.g., 'Resilience' or 'Security'.
Explanation of KV	Provide a detailed definition of the Key Value. Explain its scope, fundamental principles, and how it translates into tangible benefits or outcomes for society. Aim for 4-6 sentences. Provide citations as to where this definition comes from to support clarity as to which stakeholders' perspectives are included.
Relevance to 6G	Explain <i>why</i> this value is important for 6G. For example, describe the risk of widening an existing divide or creating new forms of exclusion if this value is not prioritized from the outset. Explanations should not be about technical improvements but be about the impact of 6G on the world it is entering into.

2. Sub-Objectives

Break down your Key Value into specific sub-objectives. This helps turn abstract ambitions into practical goals. Doing so provides clear direction for your activities.

Sub-objective 1 short title	List and describe distinct, actionable sub-objectives that must be achieved to fulfil the overall Key Value. Each objective should be defined with a title and a brief explanation. Include as many sub-objectives as are relevant.
Sub-objective 2 short title	
Etc.	

3. Stakeholders and Pain Points

Next, understand who is affected and what challenges they face in relation to the objectives. This helps position your goals in real-world needs. It also helps identify whose perspectives should inform design, testing, and evaluation.

Instruction: Identify key stakeholder groups and detail the specific challenges or "pain points" they currently face that the successful adoption of this Key Value would illuminate or help solve. Stakeholders listed here are a sampling of ones to consider relevant for impacts. Perhaps your value will not impact these but will impact others. Below are some examples.

Stakeholder	Their potential pain-points the KV could help illuminate
Individuals/End-Users	Pain point description (e.g. focus on accessibility, affordability, and digital skills gaps.)
Community Groups/Organisations	Pain point description (e.g. focus on cultural relevance, representation, and advocacy gaps.)
Governments and Public Sector	Pain point description (e.g. focus on regulatory challenges, equitable rollout financing, and preventing digital divides.)

Technology Developers/Providers	Pain point description (e.g. focus on commercial viability of inclusion features, complexity of diverse user requirements, and ethical design.)
Stakeholder Name...	Pain point description

4. Impact

Map potential impacts and decision pathways. This shows how different stakeholders could benefit or be disadvantaged by your project's outcomes. This step turns abstract value statements into practical insight on accountability and risk management. It also clarifies the purpose of the assessment, e.g. who uses the evidence that will be produced and for what purpose (e.g. how it impacts decisions that can be made).

How Can Stakeholders Benefit?

Instruction: Describe the potential positive and negative impacts within this Key Value frame for each stakeholder group. This is where you start to envision success factors and what the world should look like if you do things right. These should consider a few features:

- a) Scope of impact
- b) Significance of impact
- c) First or second order nature of impact

Stakeholder	Positive and Negative Impacts	Scale and Significance
Stakeholder 1		
Stakeholder 2		
Etc.		

What Actions or Decisions Will Result?

Instruction: Identify who uses the assessment results derived from this KV and what kind of decisions they would make based on those results. This might not be all of your stakeholders; mostly likely most will readily receive value without actively making decisions as a result of an indicator.

This step is vital to designing a good indicator. Indicators are intended to be used by someone to make a decision. So, prior to being able to develop an indicator, the purpose behind it needs to be clear. What kinds of change is being monitored, what decisions will be made by who? For example, an indicator for an engineer to make a design change, for a marginalised end-user to decide if a technology will benefit them, or for a funding body to assess impact will all require different kinds of assessments.

Stakeholder	What is the purpose of an assessment of this value for the stakeholder?
Policymakers/Funders	How results are used (e.g., prioritize funding, develop regulations, enforce standards.)
Technology Developers	How results are used (e.g., design changes, bias mitigation, evidence for use case effectiveness.)
End-Users	How results are used (e.g., informed adoption, advocacy campaigns, monitoring accountability.)

Stakeholder...	
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5. Technology and Use Case/PoC Implications

Connect your sub-objectives to specific technologies you are working on and consider how it should impact your use case planning. This demonstrates how societal aims translate into technical design choices and helps articulate the rationale behind design priorities. If you don't have use case/PoCs to put your activities into (e.g. super low-TRL and more basic research around technological advancement) one option is to articulate the various ways this basic research could advance value-based activities in general.

Affecting Use Cases/PoCs

Instruction: For each Sub-objective from section 2, explain how it must influence the design and prioritization of details within 6G use cases/PoCs. Providing a key guiding question can help focus development.

Sub-objective	How might it affect use cases?	Key Guiding Question
Sub-objective 1 short title	Use Case Impact (e.g., Prioritize basic, affordable connectivity for essential services.)	Key Guiding Question
Sub-objective 2 short title	Use Case Impact	Key Guiding Question
Sub-objective 3 short title	Use Case Impact	Key Guiding Question

Affecting Technology

Instruction: List the specific technological enablers, features, or architectural components that you are working on that are most implicated by each Sub-objective. This is not an exhaustive list, and it does not require 3 per line. The aim is to map key technology development activities in the project to the sub-objectives in order to articulate how the different technology pieces connect to the impact mapping already done in the previous steps.

Sub-objective	Technological Enablers Implicated
Sub-objective 1 short title	Technology Enabler 1, 2, 3. Provide very short explanation as to why/how.
Sub-objective 2 short title	Technology Enabler 1, 2, 3. Provide very short explanation as to why/how.
Sub-objective 3 short title	Technology Enabler 1, 2, 3. Provide very short explanation as to why/how.

6. Key Value Indicators (KVI)

Turn the intentions from above into evidence. Now that you have the who, what, why all mapped out, it starts to become possible to translate values into measurable evidence. A KVI is not just a performance metric; it captures meaningful signals that your activities are

advancing the intended societal, environmental, or economic value. The goal is to make the link between technology development and value creation visible, credible, and actionable. See “what is a good KVI” sheet for support.

Start by revisiting your Sub-objectives, Stakeholders, and Decision Uses (from Steps 2–4). Ask yourself:

- What observable changes or signals would show progress toward this Key Value?
- Who needs to see that evidence, and in what form, to make decisions?
- Can this indicator be measured during development (to guide design), or only after completion (to demonstrate outcomes)?

A good KVI often combines a measurable feature (e.g., “percentage of underserved users gaining access”) with a qualitative or contextual layer (e.g., “users report increased trust or autonomy”). You may also draw on existing sustainability or social impact metrics (e.g., OECD well-being metrics, EU digital inclusion measures, Social Value International Indicators) to anchor your KVIs in recognizable frameworks.

The key is that each KVI should make the link between technology activity and societal value visible, credible, and actionable, allowing teams and decision-makers to adjust direction or confirm pathways as evidence builds. If no action can be taken from a KVI, then it is just a description to make a claim, not an indicator.

Grounding Framework

What does previous research say about this combination of value, use case, stakeholder, and pain-point? Building a framework from a stakeholder or theoretical framework grounds the chosen indicators in existing understandings of impact pathways. It also can help outline the core elements and their relationships, helping to clarify what indicators should cover and which need to be considered together.

Instruction: List the background resources and the essential elements that your KVIs should cover each resource suggests. The aim here is to describe more systematically what you should keep in mind while developing the KVIs and to articulate the rationale behind why you chose the KVIs you did.

- **KVI Element 1:** e.g., from the OECD official indicators, equity-focused: the indicators should be able to contribute to the measurement of distribution of benefits across socio-economic groups.
- **KVI Element 2:**
- **Etc.**

KVI Formulation

Instruction: Now it’s time to define your project’s KVIs. Map the KVIs toward the sub-objectives, taking into account all the elements from the previous sections. Each KVI should directly address a stakeholder, impact or pain point and support the appropriate decision type. For each KVI, clearly identify the Stakeholder / Objective / Decision combination being addressed.

KVI	Stakeholder Impacted	Objective Aimed At	Decision it Supports
KVI 1 Short name and Description (e.g., Increase in coverage footprint in rural areas)	who would benefit/be harmed from it	Towards which sub-objective is the indicator a proxy	Stakeholder who would use the results of the KVI and to what purpose

<p>Rationale: The Rationale must explicitly explain:</p> <ul style="list-style-type: none"> ○ What observable evidence the KVI will gather; and ○ How this evidence demonstrates success in creating the intended Key Value and validates the connections made in this template. <p>example: “this KVI gathers evidence of network deployment effort, directly validating the ‘Ensuring Equal Access’ objective. The evidence [e.g., new coverage maps] connects the technological enabler [e.g., Satellite Integration] to the intended stakeholder benefit [e.g., Rural Communities gain access].”</p> <p>If possible, also note where the KVI, or the rationale behind the proxy, originates (e.g., existing standard, consultation with stakeholders, previous literature, or continuity from an earlier project).</p>			
KVI 2			
Rationale:			
Etc.			
Rationale:			

APPENDIX C – EXAMPLE VALUE SHEET APPLIED TO A USE CASE

Use case: In wildfire-prone regions, vulnerable populations often face life-threatening gaps in emergency communication due to physical, financial, or informational barriers. 6G-enabled Public Protection and Disaster Relief (PPDR) networks can transform this reality by ensuring everyone receives life-saving alerts and evacuation guidance, regardless of who they are or where they live. When wildfires spread rapidly and traditional infrastructure fails, people in remote rural areas stay connected through D-MIMO technology. First responders gain the situational awareness and resource planning capabilities, powered by AI-driven systems and lightweight computation, they need not only to fight fires effectively but to evacuate and protect all community members equitably.

Inclusivity in and by 6G (Digital and Social)

1. Key Value Definition

Pillar: Societal

KV: Inclusivity (Digital and Social)

Explanation of KV (for the use case):

Inclusivity underscores the importance of ensuring that all individuals and groups, regardless of socioeconomic status, geographic location, or personal ability, have equal opportunities to access public services and emergency resources. **Social inclusivity** involves efforts to improve the terms of engagement for marginalized individuals and communities, ensuring equitable representation and participation. **Digital inclusivity** emphasizes rural accessibility, affordability, and digital skills needed for individuals or communities to make use of the access provided.

Relevance to 6G: Overall aim is to ensure that 6G technologies help reduce the digital divide by addressing systemic barriers, like limited infrastructure, affordability, and lack of digital literacy.

2. Sub-Objectives

- **Ensuring access, both physical and economic:** Creating access to technology and services for all, including underserved and marginalized communities, accounting for income disparities and geographic challenges.
- **Promoting digital literacy and skills:** Focuses on ensuring people have the confidence and knowledge to meaningfully use digital tools for disaster response.
- **Equitable outcomes:** Providing equitable opportunities to obtain resources, participate in society, and benefit from disaster response services.
- **Supporting vulnerable and marginalized communities:** Empower groups facing systemic disadvantages, building social resilience.

3. Stakeholders and Pain Points (What's at stake for who?)

Stakeholder	Their potential pain-points the KV could help illuminate
Vulnerable groups	Affordability of access and lack of representation in design, such as those most vulnerable to the harms of disasters (e.g. elderly, children, those with disabilities, etc.).
Rural Communities	The high cost and logistical challenges of deploying dense 6G infrastructure in sparsely populated areas make them less commercially attractive for providers. Even if regional hubs exist, the

	“last mile” challenge often results in unequal access and resiliency issues. They also face the physical challenges of infrastructure.
Disaster Responders	Rural areas, or areas experiencing disasters often have less or no connectivity. These areas are also often less rich with smart city tools, like sensor networks and citizen communication routes.
Governments and Public Sector	Securing sufficient public funds or incentivizing private investment for equitable 6G rollout, especially in unprofitable or underserved areas. Challenges in developing adaptable regulatory frameworks that ensure broad access while balancing innovation and market forces, and preventing the exacerbation of existing digital divides.
Technology Developers/Providers	Investing in equitable deployment models may not offer immediate or high commercial returns.

4. Impact

How Can Stakeholders Benefit (from engaging this value)?

Stakeholder	Positive and Negative Impacts	Scope and Significance of Impact
Vulnerable groups	Greater access to emergency services and the well-being/resilience that results. A stronger voice and sense of belonging in the digital society. Negative Impact: additional costs, lack of digital skills, new forms of social exclusion.	Scope: Impact extends beyond pilot participants to inform last-mile standards that could affect similar regions across EU fire prone regions. Significance: medium increase in access to emergency services.
Rural Communities	Greater access to emergency services and the well-being/resilience that results. A stronger voice and sense of belonging in the digital society. Negative Impact: additional costs. Negative Impact: Widening the digital divide, new forms of social exclusion, lack of digital skills, additional costs.	Scope: Impact extends beyond pilot participants to inform last-mile standards that could affect similar regions across EU fire prone regions. Significance: medium increase in access to emergency services.
Disaster Responders	More efficient and effective delivery of public services, improved citizen trust, better overall social outcomes due to better digital tools and access. Negative: additional costs and training needed, changed procedures, managing public expectations.	Scope: providing a set of requirements for connectivity in rural areas that are both affordable and representative of different rural regions. Significance: small affect on industry activities.
Governments and Public Sector	Greater ability to address vulnerable populations and disaster prone areas’ needs, fostering more resilient and self-sufficient communities. Negative impact: widening the digital divide, added overhead.	Scope: providing evidence to policymakers at the EU level. Significance: Directly influence drafting of 1-2 key regulatory proposals.

Technology Developers/ Providers	Market differentiation, wider stakeholder relations, regulatory alignment. Negative impacts: increased development costs, technical complexity, data governance burdens.	Scope: on example of how to make last-mile connectivity cost-effective. Significance: Demonstrated pathway for technology providers to reach underserved markets.
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What Actions or Decisions Will Result?

e.g. who makes decisions around this objective? What kind of decisions?

Stakeholder	Who would use the results of assessments within this value frame? How?
Rural Communities	To better assess if a new technology, and the responders using it, can be trusted. To understand how to modify activities for better response results.
First Responders	To determine if a technology will be usable in their local situation To determine if it will improve their response effectiveness.
Governments and Public Sector	To develop policies and funding that encourage development in areas where 6G is lacking. To supporting literacy programs.
Technology Developers/Providers	To modify design to be more inclusive. To provide evidence that the use case is effective in fostering resilience.

5. Implications for Technology and Use Case/PoC

Objective	How might it affect use cases?
Ensuring equal access	The use case should prioritize activities that emulate rural areas, focusing on questions of connectivity in challenging situations. <i>Key Question: How does 6G explicitly ensure basic, affordable, and equitable connectivity for disaster response in rural areas?</i>
Promoting digital literacy and skills	The use case should offer capacity building opportunities, both to start to grow such skills and to identify what training would be needed in the future. It should prioritise the kind of skills needed to use, maintain, repair, etc, and include these participants in any lab activities and trials. <i>Key Question: How do the activities foster digital literacy and confidence in communities to use 6G-enabled technologies?</i>
Equitable Outcomes	The use case should demonstrate that 6G technologies lead to measurable improvements in resilience for underserved communities. Key Question: How do the activities demonstrate that 6G delivers tangible improvements in underserved communities?
Supporting vulnerable and marginalized communities	The use case would specifically address the unique challenges faced by vulnerable groups, such as enabling support for isolated elderly or facilitating transparent aid distribution for displaced populations. <i>Key Question: How can 6G leverage capabilities that support the specific challenges faced by vulnerable groups facing disasters?</i>

Technology Enablers

Objective	Technological Enabler (lists built from existing project activities that tag this KV)
Ensuring equal access	<ul style="list-style-type: none"> • Lightweight computational solutions (Reduces latency, improving accessibility) • Equipment agnostic/reusable solutions (Reduces hardware cost and dependency) • Temporary Connectivity Solutions in Rural Areas (Addresses unreliable connectivity in agricultural areas) • Cost efficient network deployments, solutions.
Promoting digital literacy and skills	<ul style="list-style-type: none"> • No technology, just practices in this use case.
Equitable Outcomes	<ul style="list-style-type: none"> • D-MIMO structures (as a temporary communication network, making it good enough to use in difficult situations)
Supporting vulnerable and marginalized communities	<ul style="list-style-type: none"> • AI-driven triage on the edge (running models that consider vulnerability features for local resource allocation decisions).

6. Key Value Indicators (KVI)

Grounding Framework

Vulnerability in disasters is situational and context dependent. While households may face the same spatial risk (e.g., equal likelihood of flooding), vulnerability differs based on factors such as pregnancy, old age, limited finances, lack of social connections, or inadequate local infrastructure [1]. Social and demographic contexts (e.g. socioeconomic status, gender, age, health inequalities, disability, ethnicity, and religious, cultural and language factors) shape community risk and resilience [2]. Assessment must use disaggregated data to identify those served least by traditional services due to barriers in access, engagement, or service [1].

Effective technology must demonstrably address constraints that prevent engagement during crises: physical, financial, informational, attitudinal, and institutional [3]. Assessment should examine whether addressing these barriers increases cost-effectiveness of disaster risk management and advances social inclusion [4], and whether the technology strengthens social and community networks [5]. Non-statutory partners, including voluntary, community and faith sector representatives, should be involved in project activities to increase understanding of available support capacities [2].

Assessment should evaluate technology against four protective factors: Wellbeing (health and psychological coping ability), Connection (social capital and environmental links), Knowledge (access to and understanding of hazard information with capacity to act), and Security (shelter, safety, and financial protection) [5]. This includes whether the system adapts responses to individual needs through accessible formats and personalized support.

The Sendai Framework requires all-of-society engagement with empowerment and inclusive, accessible, non-discriminatory participation (e.g. Sendai Framework). Vulnerable actors must be involved in decision-making to: engage organizations holding specialist knowledge including lived experience; build responder capacity through training; establish effective data gathering and sharing mechanisms; and ensure governance structures integrate policies, coordination mechanisms, and stakeholder risk communications into emergency preparedness [6] [2] [7].

KVI Formulation

KVI	Stakeholder Impacted	Objective Aimed At	Decision it Supports
Geographic Coverage: Geographical area where the solution is offered relative to the area of interest.	Rural Communities, Technology Providers	Ensuring equal access	To determine if a technology will be usable in their local situation & To modify design to be more inclusive. (Dimension 1)
Rationale: Rural and remote populations face distinct infrastructural vulnerabilities, including denial of access to essential infrastructure and transport routes. Unequal geographic distribution perpetuates the pattern where those most vulnerable are least supported. Geographic coverage directly measures whether technology work towards eliminating some of these barriers.			

KVI	Stakeholder Impacted	Objective Aimed At	Decision it Supports
Accessibility for All: percentage of critical safety alerts and data accessed without cost by the targeted vulnerable population during the emergency	Vulnerable groups, Technology providers	Supporting vulnerable and marginalized communities	To provide evidence that the use case is effective in fostering rural resilience. (Dimension 2)
Rationale: Financial constraints are a primary barrier preventing vulnerable persons from engaging during crises. This indicator helps assess whether financial barriers still exist to life-saving services.			

KVI	Stakeholder Impacted	Objective Aimed At	Decision it Supports
Stakeholder Representation: Percentage of targeted vulnerable population (disaggregated by disability/age/ethnicity) living in potential D-MIMO coverage zones	Disaster Responders, Vulnerable groups, Rural Communities	Supporting vulnerable and marginalized communities	To determine if a technology will be usable in their local situation (Dimension 3)
Rationale: This indicator uses disaggregated population-level data to identify whether technology serves those historically underserved by traditional services. Different vulnerability characteristics (e.g. disability, age, gender) intersect with spatial risk differently.			

KVI	Stakeholder Impacted	Objective Aimed At	Decision it Supports
Stakeholder inclusion rate: ratio of stakeholders engaged in the project activities who are representatives of marginalized/ vulnerable community groups compared to those who are not.	Rural communities, vulnerable groups, Technology providers	Equitable Outcomes	To provide evidence that the use case is effective in fostering rural resilience. (Dimension 4)
Rationale: The Sendai Framework requires mechanisms ensuring vulnerable actors are involved in decision-making. This indicator assesses whether the technology development process fulfils inclusive governance requirements.			

KVI	Stakeholder Impacted	Objective Aimed At	Decision it Supports
Difference between the evacuation of general	Disaster Responders, Rural communities, vulnerable groups	Equitable Outcomes	To better assess if a new technology, and the

population vs vulnerable residents.			responders using it, can be trusted. (Dimension 4)
Rationale: This indicator measures whether responses adapt to individual needs to provide safety. Evacuation time differential reveals whether the first responders, with the support of the new solutions, are able to protect equitably.			

KVI	Stakeholder Impacted	Objective Aimed At	Decision it Supports
Digital literacy	Disaster Responder; Policy Makers	Promoting digital literacy and skills	To supporting literacy programs (Dimension 3).
Rationale: This indicator assesses the knowledge protective factor—whether people have access to, understanding of, and capacity to process and act upon technology-enabled information meaningfully			

KVI	Stakeholder Impacted	Objective Aimed At	Decision it Supports
Societal Readiness Level: Community capacity to use and act upon solution.	Policy Makers	Ensuring equal access	To develop policies and funding that encourage development in areas where 6G is lacking.
Rationale: Low societal readiness creates attitudinal, informational, and institutional barriers. This indicator operationalizes the all-of-society engagement requirement by ensuring communities are empowered partners rather than passive recipients.			

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