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Human Values as the Basis for Sustainable Information System Design

Article (Draft)

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ABSTRACT: Information Systems have an increasing impact on individual well-being, the environment, and our society. As a result, they are part of the global debate on sustainability. To mitigate potentially harmful effects and enable sustainable systems, scholars suggest considering human values during system design. As human values can play such a fundamental role, this article builds a bridge between these and dimensions of sustainability. The article consolidates values from multiple sources into one single extensive collection, which allows innovation- and engineering teams to get an overview of what might be relevant to consider, especially if they seek their systems to be sustainable. The value collections hence supports requirements engineering practices, but it also offers the opportunity for broader and more sustainable customer value propositions.

KEYWORDS: human values; sustainable development; software engineering; requirement engineering; value sensitive design

I. INTRODUCTION

When companies face the question of “sustainability” they often associate it with extra cost and burden on their operations. As a result, many view sustainability more as a challenge than an opportunity. In this article, we claim that companies should rethink this attitude, because sustainability can be understood as deeply rooting in human values. Seen as such it has a direct connection to the core of any business model: the customer value proposition.

To present our argument, we build on a widely accepted definition of sustainable development as a “development that meets the needs of the present without compromising the ability of future generations to meet their own needs” [1, p.2]. This definition comprises two parts of equal importance: the meeting of needs as one corporate goal and the care for long-term side effects as a second goal. The meeting of needs is what companies strive for most, because it is their excelling at this task that makes customers initially buy and consume their services. This is true for software systems or digital services just as much as it is for classical products. But what needs and values are important? Below we show what values companies could consider as relevant for their systems and thereby address the needs side of sustainability. Secondly, we show how values can be used to anticipate negative side effects of products and services. Value based thinking helps to anticipate what can go wrong [2] and thereby support the second ambition of sustainable development: to not compromise the needs of future generations.

In this article, we focus on information systems, as these play an increasing role for individual well-being [3], for the environment [4] and for society at large [5]. Considering sustainability in information system (IS) development is therefore become paramount. IS are sustainable when they embrace human values and thereby exert positive effects instead of just seeking for efficiency and profit [6, 2].

We focus on sustainable IS in this article in two steps: In the next section we first show how the theory of sustainability is linked to human values. In a second step we then accumulate a

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human value collection that we built up from various disciplines and leading sustainability institutions. This aggregated cross-disciplinary value collection aims to pragmatically support companies and their engineering teams. It helps them to understand what values are, which ones are out there and it thereby broadens their creative process when reflecting on the needs and concerns customers might have.

II. The link between Sustainability and Human Values

Penzenstadler and Femmer [10] proposed a generic model that allows considering aspects of sustainability during requirement engineering. Their hierarchical model consists of a top-layer with five interrelated sustainability dimensions served by a middle-layer consisting of values, indicators and regulations, and a low-layer with activities contributing to specific values or a set of them [10]. The elements of the middle-layer are closely related to each other, as for instance regulations can be formalized as human values (e.g.: data protection laws enforces privacy). The five dimensions include: *Individual sustainability* concerned with the maintenance of human capital such as health, education, knowledge, leadership and access to services that constitute human capital [10, 11]. *Social sustainability* focuses on social capital and on preserving the solidarity of a society. This includes effects of IS on communication, interaction and governance [10]. Systems should facilitate activities or processes that directly or indirectly create benefits for social communities [12]. *Economic sustainability* aims at preserving assets, which do not only include capital, but also add value in form of interest [10, 12]. To foster economic sustainability, systems should ensure that long-term investments are protected from economic risks [10]. *Environmental sustainability* seeks to improve human well-being by protecting natural resources [10]. And finally, *technical sustainability* ensures long-term usage and appropriate evolution of systems, while considering the rapid change of use contexts and requirements [10, 12]. An exemplary excerpt of the model layers can be seen in figure 1. According to Penzenstadler and Femmer [10] sustainability is only achievable if all five dimensions are accounted for. However, current IS development practices typically focus almost exclusively on the technical and economic dimensions [12] thereby neglecting vital aspects of sustainability and ignoring potential customer values.

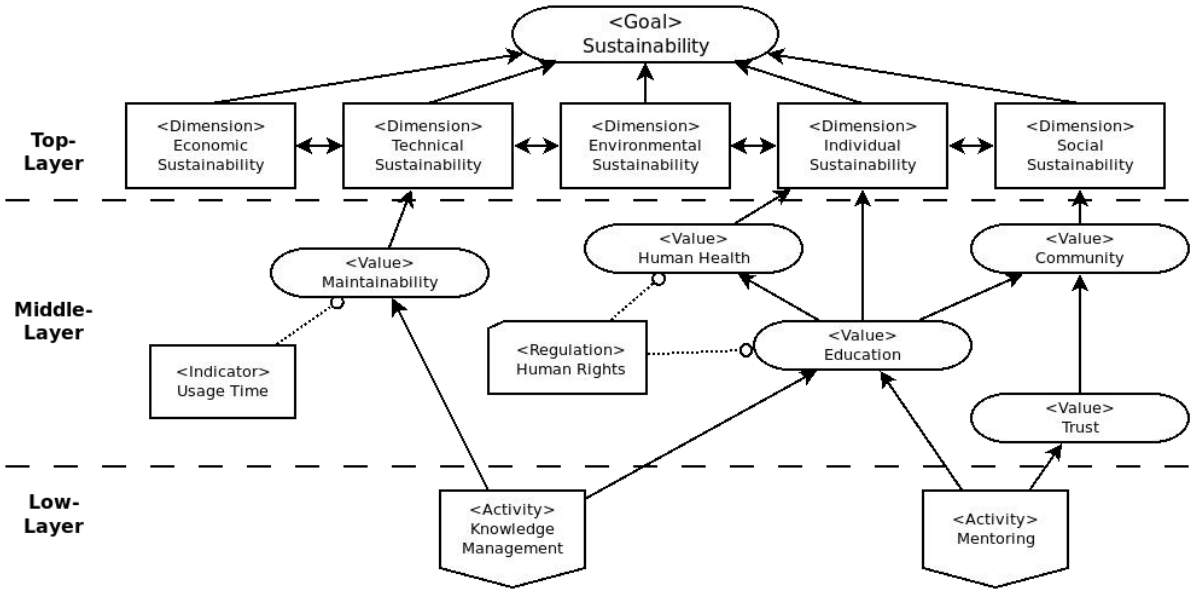

Figure 1. Exemplary excerpt of the generic sustainability model [10]

In order to drive the multitude of sustainable IS dimensions it is essential to have insights into the broad spectrum of existing human values. Guidance is needed as to which set of values fosters respective dimensions of sustainability. Such guidance is especially useful as IS are

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often developed under time pressure and with limited resources to establish such insights during project realization. Additionally, while many engineers might have intuitive ideas about what values are, many might lack the interest in disciplines, which have been traditionally involved in studying human values, such as the social science, psychology, philosophy, anthropology and others. Each discipline has produced a rich understanding of what values exist and mean, based on their own unique research perspective. This knowledge should be made more available to the engineering discipline.

Our goal in this article is therefore to accumulate a broad human value collection, built up from various disciplines and leading sustainability institutions. This aggregated cross-disciplinary value collection will support companies and their engineering teams by giving them a structured overview of existing human values and how these are related to sustainability goals. The list might also broaden their creativity to address immediate customer value needs.

III. Values, Goals and Principles

Values are an explicit or implicit representation of the desirable, which influence our selection from available modes, means and ends of actions [9]. Technical systems or objects can "carry" values when they possess respective value „dispositions" [44] or affordances that can be engineered into them. Value dispositions can be of technical and organizational nature.

For the context of sustainable development, Kates et al. [1, p.7] specify that values "invoke feelings, define or direct us to goals, frame our attitudes, and provide standards against which the behavior of individuals and societies can be judged." Similarly, in psychology, values are considered as a concept that represents desirable behaviors, end states or trans-situational goals; values are shared by culture, ranked differently by individuals and can be the source of a person's self-esteem [14]-[16]. The relative importance of values depends on the person's culture, socioeconomic status, practical context [16, 17] and very personal „ordo amoris"(order of the heart) to speak with the words of philosopher Blaise Pascal. These definitions suggest that stable long-term goals (or trans-situational goals) can be conveyed as values. It is not surprising then, that important catalogs for sustainable development, such as the benchmark goals of the Millennium Declaration, are expressed as values [1]. Furthermore, the goal of sustainable development is often defined through the values that represent or support it [1, 18]. For instance, values like respect for nature or shared responsibility are typically part of the sustainable development definition. Some values are so important that they have even been presented as rights; for instance the values embedded in the Universal Declaration of Human Rights [33], such as equality, freedom and security. Sustainability frameworks typically recognize these rights as fundamental values to respect.

Important to note is that values do not come in isolation: „Values condition each other, in that it is not possible to grasp some value without having grasped some others" [44, p.79]. Against this background, our effort to create a value collection below is marked by broader values that are accompanied by a spectrum of related values, which describe more specific aspects. For instance, the value of "security" can have specific aspects described by other values such as "national security" or "food and water security". Broader values that are accompanied by related values are called "overarching values" from here on. Overarching, because they serve as an umbrella to multiple values that are instrumental to them. Furthermore, to achieve our goal to support sustainable IS development, we group the value collection according to Penzenstadler and Femmers five dimensions of sustainability as depicted in figure 1.

IV. Method and Sources

We initially conducted a literature overview, looking for highly cited contributions, which explicitly present value lists and include the keywords "value sensitive design", "sustainable

software development" or "software engineering ethics". Based on the major contributions we identified, we then used a snowball procedure to identify other relevant and cited value sources from such fields as design, engineering, psychology, philosophy, ethics, sustainability and human rights. Additionally, we included value lists from well-known political and non-governmental institutions that care about sustainability. Finally, we reached out to standardization bodies and think tanks that are now engaged with the ethics of artificial intelligence (AI) and therefore publish AI related value.

Every source enlisting values, goals or principles was treated as equally relevant and therefore included. Taken together, we identified 26 sources explicitly presenting values. In the following you can see a summary and short description of these sources, categorized according to the disciplines from which they originate. The stated values, goals and principles add up to 355.

Design and Engineering

- *The 12 Principles of Green Engineering:* A framework for scientists and engineers to design materials, products, processes and systems beyond baseline engineering qualities, which enables them to consider environmental, economic and social factors [19].
- *Value-sensitive Design:* A design framework for incorporating human values into technology design, which mainly commits to thirteen values with ethical importance [20].
- *Social Dimension of Sustainability:* A list of ten values depicting social aspects of software [21].
- *ISO/IEC 25010 Product Quality Model:* A model comprised of eight quality principles, which describe the degree to which a system satisfies the needs of various stakeholders [22].
- *Values for Assistive Technology Devices:* A list of values based on multidisciplinary literature that are important for the development of assistive technology devices [23].
- *Sustainability Properties of Software Projects:* A list of eleven properties relevant for the sustainability of projects [24].
- *Software Engineering Code of Ethics*: A code of ethics that emphasizes the professional's obligations to the public, supported by the ACM and IEEE [25].

Sustainable Development, Law and Human Rights

- *UN Millennium Declaration*: A declaration based on 60 specific goals, which are articulated as a set of six fundamental values seen as essential to international relations [2]. This declaration was adopted by 147 world leaders in 2000 [26].
- *Earth Charter*: An ethical framework for building a just, sustainable and peaceful society, resulting from a decade-long, worldwide, cross-cultural dialogue on common goals and shared values [27]. It summarizes 50 international law instruments, their core values and principles [28].
- *Sustainable Development Goals for People and Planet:* A list of sustainability "must-haves" for human prosperity. It builds upon recent credible scientific studies and existing international processes [29].
- *Sustainable Development Goals:* A list of seventeen goals building on the Millennium Development Goals, but also includes new areas such as climate change, sustainable consumption, justice and others [30].
- *Millennium Development Goals Report:* A collection of eight goals, representing a broad vision to fight poverty in its many dimensions. It was laid-out by world leaders at the beginning of the new millennium [31].

- *ISO 26000 Principles of Social Responsibility:* A list of principles that can assist organizations in contributing to sustainable development by encouraging them to go beyond legal compliance [32].
- *Universal Declaration of Human Rights:* A declaration drafted by representatives with different legal and cultural backgrounds from all over the world [33].
- *European Convention of Human Rights:* A major piece of legislation that aims to establish effective systems for supervising and protecting fundamental rights and freedoms [34].

Psychology, Philosophy and Ethics

- *Rokeach Values:* A list of 36 values that is the result of reducing the vast number of values mentioned in the literature. This was achieved by interviewing and choosing those values that were maximally different conceptually and minimally inter-correlated empirically [35, 15].
- *Human Values by Schwartz:* A value list that is the result of a cross-cultural study on the universal aspects in the structure and content of human values [15]. This study is partially based on the work of Rokeach [35] and provides evidence that many people across societies implicitly recognize ten value types as important [15].
- *Intrinsic Values by Frankena:* A list of values that is the result of the philosophical work by William Frankena on value ethics. His list grasps the essence of what is desirable in life and what should be pursued for oneself and others [36].
- *Ethical Principles for experimental technology:* A set of six moral principles for evaluating experimental technology, based on principles for clinical experiments that can be found in the Nurember Code, Helsinki Declaration and Common Rule [37].
- *Maslow's 8-Stage Hierarchy of Needs*: A motivational theory that assumes that people have the goal to achieve certain needs [38]. The well-known original five-stage model has been expanded to include cognitive, aesthetic and transcendence needs [39].
- *Aristotle's List of Virtues*: A list of virtues necessary for human flourishing [40]. While virtues are a slightly different concept than values, it is still important to consider them as a major source for human capabilities.
- *The Central Human Capabilities:* A list of basic capabilities which are regarded as essential in making us human [41].

Recent AI Affords

- *IEEE Global Initiative in Ethics of Autonomous and Intelligent Systems:* A comprehensive body of work that address values, intentions and implementations of AI systems with eight general principles [45].
- *Everyday Ethics for Artificial Intelligence:* An ethical framework for practitioners that specifies virtues an AI system should possess and provides five areas of ethical focus engineers must consider [46].
- *Ethics Guideline for Trustworthy AI:* A guideline towards a robust and reliable AI systems that respect fundamental rights, ethical principles and societal values [47].
- *Ethically Aligned Design (First Edition Glossary):* Is an extensive glossary, developed as part of the IEEE Global Initiative, which provides relevant terms and human value description [48].

There is much literal and conceptual overlap among the found values, which is due to the fact that some value sources are derived from each other. Also, as shown above, values are interlinked entities. Concerning the literal congruence, a word count analysis revealed that many values are frequently mentioned literally, some even several times. For instance in the sources "freedom" came up as a value eighteen times, "security" seventeen times, "health"

and “equality” nine times each and so forth. We used such literally repeating values as overarching values and as a starting point for clustering the other literal and conceptual congruent values. In doing so, we extracted 31 categories, which now represent these broad value concepts, which are called “overarching values” in table 1. If an overarching value is directly mentioned in a source, it is mentioned as such. Any other value with conceptual congruence, was associated with an overarching value and thereby provides specific aspects of it.

V. Result: An Extensive Value Collection

Table 1 shows the identified overarching values and their associated specific aspects with reference to the sources in which they are mentioned. Our value collection provides innovation teams and engineers with values and sources that they can consider during requirement engineering. To support sustainable IS development the collection is ordered according to the five sustainability dimensions presented above [10]. The sources provide key information about found values. This is vital for a successful value oriented development project. For example, for an IS that is intended to live up to the value of equality, specific aspects such as gender equality or minority equality need to be considered. This does not mean that equality as a concept is exhaustively described in table 1 by just considering gender and minorities. But the table illustrates that these two aspects of equality have been recognized as important elsewhere and should therefore not be neglected.

This collection should not be understood as an attempt to prioritize values. Prioritizing values could lead to the exclusion of important values and would be inherently biased as many value lists are derived from each other. In fact, the relative importance and meaning of a value is always deeply context-dependent [16, 17]. Values therefore need to be examined in the intended operational context of a planned system. Such attentiveness for context also allows for cultural sensitivity.

VI. Critical Discussion of the Value Collection

From a requirement engineering perspective, the presented human values are high-level requirements. These requirements can now be broken down into more specific functional and non-functional requirements [43], a practice which subsequently allows for specification and implementation.

According to Penzenstadler and Femmer’s model [10], the dimensions in the top-layer are interrelated to each other. This implies, that a single value on the middle-layer might mainly foster individual sustainability but thereby also (indirectly) influence social sustainability. This indirect relation becomes clear, for example, when considering that human health aspects are vital for maintaining human capital and therefore individual sustainability. As human capital also forms the basis for social capital and solidarity, the relation to social sustainability is apparent.

One might notice that some overarching values, can have a direct relation to more than just one sustainability dimensions as is suggested by our table 1. Freedom for instance has a direct impact on building human capital (individual sustainability) and enables the solidarity of a society (social sustainability). Such direct and indirect relations make it difficult to reliably attribute values singularly to only one sustainability dimension. Therefore, the categorizations of values for sustainability goals should not be seen as absolute. The context-dependent nature of a value [16, 17] suggests that such a relations need to be considered in context of a planned IS.

When it comes to values from recent ethical AI efforts [45]-[47], a clear clustering around mostly technology-centered AI topics can be seen. While popularly discussed values such as transparency, security, privacy, accountability and human autonomy are regularly recognized by the AI community, other noteworthy values relevant in an AI context such as freedom, control, maintainability, property, human health or community appear to be underrepresented.

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Our value collection illustrates that AI system developers should therefore turn to more holistic and interdisciplinary value lists such as the one presented in this article to ensure sustainability and meet customer needs. Still, existing AI efforts are at least a starting-point to gather value knowledge.

As part of the IEEE Global Initiative in Ethics in Autonomous and Intelligent Systems an extensive glossary was developed [48] to ensure that relevant terminology is available for interdisciplinary teams. This glossary provides an extensive overview of relevant terms and concretely defines 23 values. Uniquely, these descriptions offer interdisciplinary perspectives on individual values combined in a single document from fields such as engineering, social sciences, philosophy and law. When studying the value concept descriptions, it is obvious that each discipline has its own distinct definition of a value; as other scholars have noted earlier [13]. This fact stresses the point that working with values can only be a multidisciplinary achievement. Our table 1 in this article is a starting point to understand what is relevant when building ethical or value-based systems. The next step is delve down into the meaning of values for the specific context of deployment.

We want to stress therefore that our value collection cannot substitute an extensive stakeholder-based value elicitation approach as outlined by authors such as Friedman et al. [42]. Such an approach tries to understand relevant values for an IS in context and might elicit values not included in our collection. However at the same time, a comprehensive value list can help to insure that important and recognized values are not forgotten.

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Table 1. Values and their specific aspects in relation to sustainability dimensions [10]

Social Sustainability	
Overarching Value	**Specific Aspects**
Accountability [20, 32, 45, 46, 47, 48]	Accountability in governance [27], Responsibility [37, 48], Liability [48]
Community [42, 48]	Inclusion [23], Participation (social, culture, politics) [21, 23, 27, 33, 34, 42], Partnerships for goals [30], Public interest [25], Shared responsibility [26, 33], Sustainability [27, 30], Socialness [21], Social Order [33], Social Recognition [35], Solidarity [26], Understanding [27], Compassion [27], Love [27]
Dignity [23, 27]	Courtesy [20], Politeness [35, 15], Protecting the vulnerable [26], Respect [23, 32, 27], Respect for all life [15, 33, 34], Tolerance [26, 27]
Justice [15, 27, 41, 47]	Asylum from persecution [33], Competent and fair [33], Distributive and procedural justice [37], Integrity and independence [25], Innocent until proven guilty [33], Just

	distribution of goods and evils [36], Strong institutions [30, 26], Fairness [46]
Relationship [39]	Affection and cooperation [36], Fair and supportive [25], Family [33, 39], Friendship [35, 36], Healthy attachments [42], Interdependence [23], Love [35, 36, 39], Marriage [33]
Respect for Norms	Democracy [26, 27], Ethical Behavior [25], Good governance [26], Human Rights [23, 26, 32, 45, 47], International norms and rule of law [32], Value Alignment [46]
Trust [20, 23, 48]	Truth [36], Integrity [48]
Technical Sustainability	
Overarching Value	**Specific Aspects**
Aesthetics [36]	Balance and Form [39], Beauty [15, 35, 36]
Efficiency [19, 24]	Cost [23], Consumption Minimization [19], Performance [22, 24], Waste Reduction [19]
Maintainability [22]	Building on existing framework (energy and material flow) [19], Feasibility [23], Operability [22], Supportability [24], Functional Suitability [22]
Reliability [21, 22]	Dependability [24], Durability [19], Resilience [21, 48], Robustness [47], Redundancy [48]
Reusability [24]	Compatibility [22], Promotion of disassembly [19], Re-configurability [19]
Simplicity	Avoidance of unnecessary capacity or capability [19], Calmness [20], Cleanliness [15, 35], Predictability [24], Reduction of complexity [19]
Usability [20, 24]	Accessibility [24, 21, 48], Design for all [47]
Individual Sustainability	
Overarching Value	**Specific Aspects**
Autonomy [20, 23, 37, 47, 48]	Independence [35], Mobility and free movement [23, 33, 42], Modifiability [24], Portability [24, 22], Right to change nationality [33], Self-direction [15], Human Oversight of AI [47], Moral Autonomy [48]
Education [30, 31, 33]	Intellectuality [35], Lifelong learning [25], Values and skills for sustainable living [27]
Human Capabilities [35, 42]	Ambitious [35, 41], Beneficence [37, 47, 48], Benevolence [15], Broadmindedness [35, 15], Courage [35, 41], Critical Reflection [42], Forgiving [35], Generosity [41], Gentleness [41], Helpfulness [35], High-mindedness [36, 41], Honest [35], Humor [41], Imagination [35], Inflatedness [41], Kindness [41], Logic [35], Power and experience of achievement [36, 15, 39], Responsiveness [35], Reminding [23], Self-Actualization [39], Self-control [27, 35], Self-esteem [36, 39], Self-respect [35, 42], Temperance [41], Tradition [15], Transcendence [39], Universalism [15], Veracity and Truthfulness [41], Virtues [36], Obedient [35], Wisdom [15, 35]
Health [27, 29, 30, 36, 42, 48]	Alerting [23], Clean water and sanitation [30, 39], Combat Diseases [31], Emergency help [23], Human life of normal length [33, 34, 42], Maternal health [31], Reduce child mortality [31], Zero hunger [30, 39]
Human Welfare [20]	Comfortable life [35], Contentment and beatitude [36], Inner Harmony [15, 35, 36], Living standard [33], Meaning [39], Salvation [35], Satisfaction [23, 36], Thriving lives and livelihoods [29], Quality of life [23]
Human Well-being [23, 27, 30, 45, 48]	Harmony [36], Life, consciousness and activity [36], Relief/respite [23], Spiritual well-being [27], Quality of patient care [23]

Knowledge [39]	Informed Consent [20, 23, 48], Open exchange of knowledge on sustainability [27], True opinion and understanding [36], Competence [45]
Pleasure [15, 35]	Adventure and novelty [36], Exciting life [15, 35], Happiness [35, 36], Hedonism [15], Cheerfulness [35], Distraction [23], Rest and leisure [33], Playfulness [42]
Property [27, 33]	No poverty [27, 30, 31], Ownership [20, 33, 42]
Economic Sustainability	
Overarching Value	**Specific Aspects**
Human Productivity	Development [26, 31], Desirable work [30, 33], Industry, innovation and infrastructure [30], Interest of client and employer [25], Integrity, reputation and high standards [25], Sense of accomplishment [35], Sustainable economic activity [27, 30], Trade unions [33]
Environmental Sustainability	
Overarching Value	**Specific Aspects**
Environment [26, 15]	Animal Life [30, 42], Biological Diversity [27], Climate [30], Footprint [24], Output pulled rather than Input pushed [19], Precautionary approach [27], Productive ecosystems [29], Renewable material and energy [19, 30, 29], Respect for Nature [26, 27], Responsible consumption and production [30], Sustainability [20, 31]
Social and Individual Sustainability	
Overarching Value	**Specific Aspects**
Equality [15, 26, 27, 30, 31, 33, 35, 42, 48]	Legal Equality [33], Gender Equality [27, 30, 31], Minority and indigenous equality [27]
Freedom [23, 26, 35, 36]	Freedom from: Arbitrary arrest and exile [33], Bias [20], Discrimination [27, 33, 34, 48], Ill- or degrading-treatment [34, 33], Slavery [33, 34], Torture [33], Freedom of: Expression [34, 36], Opinion and information [33], Thought, Belief and Religion [33, 34]
Security & Safety [21, 22, 23, 26, 33, 36, 39, 47, 48]	Family [35], Food and Water [29], National [35], Non-hazardous [19], Non-maleficence [37, 47, 48], Personal [33], Protection from the elements [39], Social [33], Awareness of Misuse [45], Data Security [48], Human Security [48]
Privacy [20, 21, 23, 33, 34, 47, 48]	Surveillance [23], Data Agency [45], User Data Rights [46], Data Governance [47], Confidentiality [48]
Social and Technical Sustainability	
Overarching Value	**Specific Aspects**
Transparency [21, 32, 45, 47, 48]	Data Access [21], In Governance [27], Explainability [46], Explicability [47]
All five Dimensions	
Overarching Value	**Specific Aspects**
Peace [15, 21, 23, 26, 27, 30, 33, 35, 36]	Disarmament [26]

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