

Theoretical definitions and models of sustainable development that apply to human factors and ergonomics

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Abstract. The human race is undeniably moving into an era of resource constraints; energy choices, water scarcity, food shortages, climate change, waste management, disparate population changes, and employment challenges. This paper presents and critically examines the prominent definitions and models of sustainable development in order to provide guidance for the theoretical and practical implementation of human factors for sustainable development.

Keywords. Sustainable development; definitions; models; Triple Bottom Line

1. Introduction

The issue of sustainability is essentially one of resource scarcity or damage; either at present or at some projected time in the future. Sustainability concerns manifest as resource depletion or absence, resource degradation, the deliberate or accidental damage of resources for short term gain, or as a misunderstanding of the complex inter-relationships between resources. For most of human history, the population size was sufficiently small that we either did not experience significant resource loss, where there were resource limitations we were able to re-locate, or resources were able to naturally regenerate. More recently, the resource limitations and resultant disruptions to natural cycles (Bates et al., 2008; Vitsousek, 1994) have led to severe human tragedies such as negative impacts on human health and wellbeing (Pimentel et al., 2007), poverty and malnutrition (Hecht et al., 2012), and social system disruptions (Wilkinson & Pickett, 2009). In the words of Hecht et al. (2012; p. 64) the challenges are multidisciplinary, immense and complex:

“we must vastly improve infrastructure for water systems, sanitation, and urban development; lessen hunger, assuage poverty, and promote human dignity; curb greenhouse-gas emissions; avoid persistent, bio-accumulative, and toxic chemicals; and protect biodiversity”.

The formal use of the term “sustainability” is attributed to von Carlowitz (1713). His treatise provided rules for preventing the overuse of natural resources (wood, in his case) so as to enable the continuous supply of this resource while still meeting human requirements (for building, heating, mining, and manufacturing). The term “sustainable development” has a more recent history, attributed to the World Commission on Economic Development (WCED; 1987). Sustainable development is primarily a social justice project focusing on equitable development to meet human needs while still recognizing that the preservation of natural resources is necessary to fulfill these needs. Johnston et al. (2007) noted, however, that there are now literally hundreds of definitions and modifications of the original WCED (1987) definition. Further, Thatcher (2012) noted

that similar definitional problems have plagued the early work of “human factors and sustainable development”. This paper presents and critically examines the prominent definitions and models of sustainable development in order to provide guidance for the theoretical and practical implementation of human factors for sustainable development.

2. Defining sustainable development

WCED (1987) is the most widely cited definition describes sustainable development as:

“development that meets the needs of the present without compromising the ability of future generations to meet their own needs”.

There are three important aspects to the WCED definition. First, the definition specifies intra- and inter-generational requirements spanning both geographical space and time. Second, there is an implicit requirement for equitable development. While not explicitly stated, the definition implies ‘just and equitable’ opportunities for all. Third, the definition is unashamedly anthropocentric (the “needs” refer to human needs not ecological needs), a stance that was reaffirmed in the Rio Declaration of the United Nations Conference on Environment and Development (UNCED; 1992) which stated that “human beings are the centre of concerns for sustainable development”.

The International Union for Conservation of Nature and Natural Resources (IUCN; 1991; p. 9) balances this anthropocentricity by placing the importance on the underpinning ecological systems when defining sustainable development as:

“improving the quality of human life while living within the carrying capacity of supporting ecosystems”.

In bringing the WCED (1987) and the IUCN (1991) definitions together, the sustainable development evaluation group, ‘Monitoring of Sustainable Development Project’ (MONET; Altwegg et al., 2004; p. 14) defined sustainable development as the:

“means ensuring dignified living conditions with regard to human rights by creating and maintaining the widest possible range of options for freely defining life plans. The principle of fairness among and between present and future generations should be taken into account in the use of environmental, economic and social resources. Putting these needs into practice entails comprehensive protection of bio-diversity in terms of ecosystem, species and genetic diversity, all of which are the vital foundations of life.”

The MONET definition (Altwegg et al., 2004) is based on a re-interpretation of the WCED (1987) definition. Apart from the obvious inclusion of biodiversity and ecosystemic needs, one of the important aspects of this definition is the reference to “environmental, economic, and social resources”. These “three pillars” of sustainable development are more commonly referred to as the Triple Bottom Line (TBL). The TBL of sustainability calls for a balance between these three aspects.

Within the TBL approach to sustainable development, some authors distinguish between weak and strong “sustainability” (Neumayer, 2003). “Weak sustainability” suggests that environmental resources can be substituted by human resources provided that the sum of the resources remains constant (e.g. improved social or economic conditions could be balanced against a loss of biodiversity in agriculture). “Strong sustainability” suggests that different forms of resources are complimentary but not interchangeable (e.g. a loss in biodiversity is also a loss in social wellness). A strict “weak sustainability” approach has been criticised (Daly, 1996; Neumayer, 2003) because many of the environmental resource aspects are difficult to monetize and therefore either irreplaceable (such as fresh air), their replacements are difficult to determine, or production waste is not factored-in. A strict “strong sustainability” approach has been criticised as being unworkable because it

would assume that we know what the requirements of future generations will be (Neumayer, 2003) or unethical because it subjugates human needs (Beckerman, 1994).

Another definition, The Natural Step (TNS; Robèrt, 2002), defines sustainable development based on the Laws of Thermodynamics. Sustainable development in the TNS definition is encapsulated by four principles where a sustainable society attempts to eliminate the: (1) concentration of materials that belong in the Earth's crust; (2) concentration of substances produced by society; (3) degradation of natural processes; and (4) conditions which prevent people from meeting their basic needs (Robèrt, 2002). The TNS definition is very similar to the IUCN (1991) definition except the emphasis is on physical scientific theory rather than theories of equity and justice. Despite the apparent stated reliance on scientific theory, Upham (2000) noted that TNS often makes rhetorical and emotional judgments that uses "science" to attract followers.

Since there are numerous variants to these definitions (Johnston et al., 2007), this summary only presented the sustainable development definitions that are most prominent in the literature. Kates et al. (2001) noted that the various definitions differ in (a) determining what is to be sustained (e.g. biodiversity, ecosystem services, community, culture, etc.), (b) what is to be developed (e.g. wealth, consumption, education, culture, equity, regions, etc.), and (c) the length of time (e.g. across a single lifecycle, inter-generational, multiple generations, indefinitely, etc.). Definitions that subjugate human needs for environmental concerns are regarded by some as ethically problematic while definitions that de-emphasise the environment from which we draw our resources are considered as non-sustainable. Beckerman (1994) goes so far as to say that definitions of sustainable development are "either morally repugnant or logically redundant" (p. 191). More recently, Redclift (2007) has even suggested that sustainable development is an oxymoron, as human development inevitably means environmental degradation. What is common to each of these definitions is that they emphasise complex systemic interactions between various human and environmental systems. The definitions differ, however, in their emphasis on human and environmental concerns.

3. Models of sustainable development

3.1 Three pillars model (also called the three circles model or the Triple Bottom Line)

Arguably the most widely known model of sustainable development is the "three pillars model" (United Nations World Summit, 2005). This model has previously been represented as pillars, overlapping circles, or a triangle. The "pillar" names change between different versions of the model and include economic capital, social capital, natural capital, environmental resources, economic growth, social progress, and environmental protection. The "three pillars model" takes the three dimensions of "environmental, economic, and social resources" and labels them as three requirements for sustainable development. In this model, sustainable development is achieved when all three pillars work in unison. There are two basic critiques of this model. First is the assumption that the "pillars" are independent constructs. Some authors argue that humans are biological entities and therefore human resources are also environmental resources and therefore cannot be independent. It is also argued that the overwhelming majority of resources that humans use come from nature in the form of ecosystem services (Costanza et al., 1997) and it is therefore impossible to separate human development from environmental development (e.g. by destroying ecosystems for agriculture, we potentially destroy access to natural resources like wood, food, and medicines). Second, is the observation that the model does not incorporate a time dimension, a core component of the WCED (1987) definition. In addition to different labels for the "pillars", there is also a lack of consensus about the

content of each “pillar” (Kates et al., 2005), where sometimes the same pillar is defined in fundamentally different ways (e.g. natural resources are defined as intrinsically valuable or they are defined as valuable insofar as they provide ecosystem services to humans in the system), or new pillars are envisaged (see section 3.2).

3.2 Prism model (sometimes called the four pillars model)

Similarly to the three pillars model, the prism model proposes a set of interlinked components. Spangenberg and Bonniot (1998) distinguish between human-made capital, social capital, human capital, and natural capital. Other four-pillar models include the basic three-pillar model but separating social capital into social capital and cultural capital (Nurse, 2006), Scerri and James’ (2010) circles of sustainability (which includes economics, ecology, politics, and culture), or the MAIN prism (i.e. environmental, economic, social, and institutional). The prism model of sustainability suffers from much the same criticisms as the three-pillar model in that these models assume that the different components/pillars are independent and that there is no time dimension built into the model, which is an essential component of the WCED definition.

3.3 Nested circles of sustainability (also egg of wellbeing model or concentric circles model)

As a partial response to the three-pillar model and the prism model of sustainability, the “egg of wellbeing model” represents the relationships between the different dimensions as concentric ovals with one oval (e.g. the ecosystem) entirely encapsulating the other oval (e.g. people). This model is drawn from the IUCN (1991) definition of sustainable development and uses the metaphor of an egg (Guijt et al., 2001), where the white of the egg (ecosystem) supports and surrounds the yellow yolk (people). The wellbeing of the egg is only considered complete when the wellbeing of each individual subsystem is achieved. The various versions of the egg model are essentially the same as the three-pillar or four-pillar model in content except that the human subsystem is considered as a single subsystem with multiple components (i.e. health and population wellbeing, wealth, knowledge and culture, community, and equity) and is entirely dependent on a healthy ecosystem. The concentric circles model is similar to the egg of wellbeing model except that there are multiple levels of subsystems; the largest circle is the natural environment which encapsulates the subsystem of human society, which in turn encapsulates the subsystem of the economy. In essence, the concentric circles model is a modification of the three circles model but emphasises that each circle is constrained. The egg of wellbeing and the concentric circles models both address the concerns about the interdependence between the subsystems, but neither model addresses the issue of the time dimension.

3.4 Two-tiered sustainability equilibria model of sustainable development

Lozano (2008) argues that the concentric circles model is highly anthropocentric and places the economic subsystem at its centre. Instead, in the first step it is argued that for real sustainable development the concentric circles/three circles should fully overlap; referred to as the “first tier sustainability equilibrium” (FTSE; Lozano, 2008; p. 1841). This first step depicts the interdependencies at a single point in time (usually the present). In the second step, the time dimension is included by depicting the FTSE as a perfect cylinder. If too much emphasis is placed on either the present or the future then the cylinder would look more like a cone (i.e. the cone would be widest at the point where emphasis is placed). To achieve sustainability across time means recognizing that what is done to achieve sustainability in the present impacts on the ability to achieve sustainability in the future. The third step therefore, involves acknowledging that sustainability is a dynamic process

which requires the time dimension to (graphically) bend back on itself to form a doughnut shape or torus. This represents the notion that decisions on sustainable development in the present, form the availability of decisions of sustainable development in the future (in a continuous loop into the future). To date, there are no systematic critiques of the two-tiered sustainability equilibria model.

4. Discussion and Conclusion

Thatcher's (2012) observation that the majority of early papers in the ergonomics and human factors field supplied no definition of sustainable development makes it imperative for us to more clearly define human factors and sustainable development. Human factors and ergonomics unambiguously emphasises the importance of the human in any understanding of sustainable development. An **anthropocentric** approach is therefore a key criterion for the definition. Second, the definition should include **complex systems thinking**. All the models contain an acknowledgement that the achievement of sustainable development requires the coordination of a complex set of interrelating factors (although there is still considerable disagreement over which set of factors to be most concerned about and the degree of interrelatedness). Third, the definition should acknowledge that the entire system is **dynamic**. The entire system will change over time in ways that are only partially predictable. Fourth, the definition should acknowledge **equitable and ethical decision-making**. The authors of early works in human factors and sustainable development acknowledge the devastating impacts on social and environmental systems and the role that human factors and ergonomics can play in addressing these concerns, although there is seldom an acknowledgement of the deep moral responsibility that this entails. The role of other aspects, especially social development and stewardship of the environment are not as well established as areas of focus within human factors and ergonomics. However, given the consistent focus on these elements in the definitions and models of sustainable development, it is evident that these aspects would also need to be incorporated if human factors and ergonomics is to fully adopt a sustainable development approach. Arguably the most complete and balanced definition is the one provided by MONET (Altwegg et al., 2004), which more appropriately balances human needs against the needs of natural systems. Similarly, the sustainable development model that most closely represents the MONET definition is the two-tiered sustainability equilibria model of sustainable development (Lozano, 2008). In many ways, this model captures the complexity and emergence that Dekker et al. (2013) encourage us to embrace. However, if this definition and model is to be adopted, more work is required to demonstrate how they articulate with human factors and ergonomics. A debate is also required to discuss whether the issue of sustainable development should only apply to the sub-discipline of 'Human Factors and Sustainable Development' or to the whole field of human factors and ergonomics. Zink and Fischer (2013) suggest that human factors and ergonomics already embrace the core principles of sustainable development, but in practice most ergonomics and human factors practices are far from consistent in their application of acknowledging the multiplicity of interrelationships between the different systems involved.

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