Principles for Re-Designing Information Systems for Environmental Sustainability

Richard Baskerville[1,2], Jan Pries-Heje[3](✉), and Jan Recker[4]

[1] Georgia State University, Atlanta, USA
baskerville@acm.org
[2] Curtin University, Perth, WA, Australia
[3] Roskilde University, Roskilde, Denmark
janph@ruc.dk
[4] Queensland University of Technology, Brisbane, Australia
j.recker@qut.edu.au

Abstract. Many information systems claim to be "green", meaning in support of environmental sustainability. But at closer look we find that these claims are often unsubstantiated; in other words, many green systems are not making any environment more sustainable. We identify three main root causes. First, the 'environment' is often ill-defined. Second, systems often overlook that 'sustainability' is a targeted function dependent on the goals of some stakeholders, which may include designers, users, organizations, policy makers, society or the planet as a whole. Third, we find that research on green information systems often overlooks conceptualizations such as ecology, environment or sustainability that originate in the sciences of the system, i.e., the basis on which information systems are built. To address these issues we present eight new design principles unique to the development of Green Information Systems that can act as prescriptive coherent design theory for developing information systems that improve environmental sustainability.

Keywords: Green information systems · Environmental sustainability · Systems design · Theory development · Design principles · Systems science

1 Introduction

In responding to increased social, cultural, and legislative pressures that expand the responsibility of firms to increase attention to environmental concerns, chief executives are increasingly turning to information systems (IS), as a solution to assist organizations in transforming to more sustainable entities [1]. Information systems have been argued to be the greatest force for productivity improvement in the last half century [2], and there is great hope that such systems can also help with the global environmental challenge [2, 3].

In response, IS scholars have started to explore the role that information systems provide might play [3–5], and have also taken steps to develop theories and artefacts that show how such systems, often labeled "Green IS", could be built [6–8].

F.J. Mata and A. Pont (Eds.): WITFOR 2016, IFIP AICT 481, pp. 14–25, 2016.
DOI: 10.1007/978-3-319-44447-5_2

Our key contention in this paper is that many of the artefacts, theories and conceptions that bear the label "Green IS" do not live up to this name. In other words, we posit that Green IS are not actually and always green, meaning that much of the existing work on Green IS falls short of the proclaimed allure "to assist individuals and organizations to make better, that is, environmentally sustainable decisions, and to enable and effectuate environmentally sustainable work practices rather than environmentally unsustainable ones" [9, p. 2]. In this paper we will discuss three problems with the current conception of Green IS on which this contention is based. We provide a new conceptualization of Green IS and derive a set of six novel design principles that can guide the development of an information system for environmental sustainability. In doing so we take an important step to address the noted Green IS design challenge [2, 10]: How do we build information systems that allow organizational and/or individual actors to perform environmentally sustainable actions and decisions?

2 Related Work

2.1 Information Systems and Environmental Sustainability

The scholarly IS discipline has been challenged to provide an understanding how IS can contribute to environmentally responsible human activity [2, 3]. The key assumption is while information technology creates an environmental load due to the electricity required for its operation and the problem of disposing of obsolete hardware, IS can also be used to reduce environmental problems by allowing process and practices to change. This is because, in theory, IS can assist individuals and organizations to make better, *environmentally sustainable decisions*, and to enable *environmentally sustainable work practices*.

The studies to date fall in two categories: empirical and design. Empirical studies have, for instance, investigated factors that influence adoption of (*any type of*) Green IS [e.g., 11, 12]. Substantive-level studies have conceptualized requirements *for some type of* Green IS, such as energy systems, or examined specific systems for specific environmental challenges such as energy consumption, greenhouse gas emissions or specific organizational initiatives [e.g., 5, 13].

A second, smaller stream of Green IS research is concerned with the design of information systems for environmental sustainability. This stream has produced a number of instantiations and theories for Green IS design. Reported instantiations include open-source systems for energy data management [6], a greenhouse gas emission tracking system for logistics processes [7], or an index system for green supplier evaluation [8]. These efforts have contributed substantive-level design knowledge through the situated implementation of artefacts but they are not presented or developed in a way that the design knowledge becomes more abstract, complete and mature and where they could be termed design theory.

Regarding Green IS design theories, in 2014 two papers were presented at conferences that provide substantive-level design knowledge: they identify specific requirements for a specific type of Green IS design theory, namely an information system for sustainability reporting [14], and an information system to manage energy consumption

[15]. In 2016, Recker [9] proposed a first class-level design theory for green information systems, which postulates that any kind of Green IS must operate on the levels of belief formation, action formation and/or outcome measurement to faithfully belong to the class of systems for environmental sustainability. We will return to this theory below.

2.2 Systems and Their Environment

For design science, the concept of an environment is not necessarily related to natural environments. It refers quite specifically to the relationship between an artifact and its context. It is important to recognize this relationship in order to avoid too much obsession with the nature of the artifact itself. The context of the artifact, its environment, is the mold in which the artifact must fit sufficiently well to accomplish its goals.

The prospects for developing and applying an artifact to successfully achieve a goal depend on three key elements and their interrelationships. (1) The purpose or goal under which the activity was taken. (2) The characteristics of the artifact itself. (3) The nature of environment in which the artifact performs.

In Simon's sciences of the artificial view [16], there are two environments. The artifact itself has an inner environment that represents its substance and organization. The second environment is an outer environment constituting the surroundings in which the artifact must operate. Simon refers to the artifact itself as a meeting point or an interface between the inner and the outer environments.

Both the inner and the outer environments can be regarded as systems. For example, a computing artifact will comprise a system of hardware and software. The hardware and software constitute the inner system and the inner environment. If this computing artifact is deployed in an organization, the organization would constitute its outer environment. To the degree that we may consider an organization as a system, this outer environment is also the artifact's outer system. Simon [16] often refers to the "inner system" and the "outer environment".

Because both environments may also be thought of as systems, we must also be concerned with the complexity of the inner environment and the outer environment. A system's complexity is proportional to the amount of information required to describe the system or to resolve any uncertainty associated with the system [17]. We must be concerned about information at two levels. One level concerns the amount of information flowing across the artifact interface between the two environments. A second level concerns the amount of information necessary to properly specify the artifact's inner environment characteristics in order to match its outer environment across the interface. It also concerns the amount of information necessary to resolve the uncertainty about the artifact's inner environment behavior within the context of its outer environment. Complexity can emerge from the richness of the outer environment. The ability for the artifact to apprehend information about the outer environment across its interface can be seen as a major limiting factor in coping with outer environmental complexity.

Because of the high complexity, it can be impossible to obtain sufficient information to eliminate all uncertainty for many outer environments. Artifacts must often adapt or cope with variations in the outer environment. Such variations could be emergent change or unpredicted environmental conditions. Consequently the inner system may be regarded as a system of organized phenomena capable of attaining the goals in some range of environments. The outer environment is expected to operate across this range. Consequently the outer environment delivers the conditions under which a properly designed inner system will adapt to that outer environment and attain the goals. In this way the conditions of the inner environment are largely determined by the conditions of the outer environment.

The substantive rationality of an inner environment in the way it adjusts to its outer environment constitutes its ability to discover appropriate adaptive inner environment conditions. Thus the limits of the inner environment to discover appropriate adaptive behavior constitute the limits of the inner environments procedural rationality. These are limiting properties of the inner environment appear at the interface and reveal the degree to which the inner environment matches the outer environment. In this way these limiting properties explain artifact defects by tracing them to the inner constraints on adaptivity.

2.3 Systems and Their Design

Information systems development (ISD) regards the design of processes and products. ISD typically unfolds in a series of stages such as analysis, design, coding and testing. The stages do not have to be carried out sequentially but can be done more or less in parallel. Often each stage operates with a defined notation and will often result in a prescribed artefact, such as a requirements specification or a computer program.

An ISD methodology is a prescribed and prepackaged way of carrying out the development. The package will typically include: (1) activities to be performed; (2) deliverables or artifacts resulting from the activities; and (3) principles for organizing the activities and attaching people to perform the activities. Many ISD methodologies claim to be of generic use. However, an ISD methodology can also be aimed at a specific type of design and development such as Green IS or sustainable systems.

A key question has been whether ISD methodologies were actually used in practice? This question was raised more than 20 years ago when Bødker and Bansler [18] could not find the prescribed use of structured analysis and design in practice. Following that a growing number of studies suggested that the relationship of methodologies to the practice of information systems development was altogether tenuous [19, 20]. At a point it seemed as if the concept of methodology had taken such a dominant role in our thinking about IS design and development that it had become a self-confirming hypothesis; such a thing had to exist. An alternative viewpoint was that IS design and development in reality was emergent and therefor 'amethodical', meaning that there was no predefined sequence, control, or rationality in practice [21].

3 Three Problems with the Current Conception of Green IS

There are four key assumptions about the design of Green IS that deserve careful distinction. These assumptions include *green, sustainability, ecology, and environment*.

The *green* concept entails the relationship between information systems and the natural environment. It implies a consideration of the relationship between people and nature. It spans issues dealing with the ways in which humankind is deteriorating or destroying the planet Earth. It entails an objective: creating information systems that reduce, or at least do not worsen pollution, biodiversity loss, global warming, the greenhouse effect, and other negative impacts that people create through modern social, economic, and political development [22].

The *sustainability* concept usually regards the capacity to meet the needs of the present without compromising the needs of the future [23]. Sustainability can regard the capacity of a design artifact to operate without triggering deterioration of its outer environment. Such a system-based conceptualization of sustainability provides a more general notion that encompasses both green and other forms of sustainability.

The *ecology* concept usually regards the interrelationships between organisms and their environment. However it can also be applied to systems which have a character that behaves in organic or organic-like ways. In an inner sense, sustainable ecological systems can be regarded as stable. In an outer sense, where the outer environment is itself unstable, sustainable ecological systems can be regarded as resilient [24].

The *environment* concept is also often used in its green sense, meaning the natural environment that is the surroundings or conditions in which a people, animals and plants lives or operate.

On basis of these four assumptions, we identify three problems in the current Green IS literature. **One problem** is the lack of clarity in distinguishing green as a goal or requirement from green as a characteristic of the artifact. For example, the artifact may be green in an egoist sense of “do no harm” to the environment around it. However, it may at the same time fail to be green in the utilitarian sense of helping to restore our polluted, overheated planet to a previous state that was more desirable: a less polluted, less warm planet.

A **second problem** is that references to the “environment” are often laden with assumptions, ill-defined and examined in isolation. From a systems perspective, the outer environment of an artifact goes no further than defining the necessary characteristics of its interface, and the functions required of the artifact. However, the environment can and must be seen from many perspectives; natural, economic, organizational, social, ecological, ethical and so on.

A **third problem** is that systems designers can easily overlook the alternative scope of sustainability requirements. Sustainability is not only relative to inner and outer artifact environments, but it is also a function targeted at the goals of some stakeholders. The sustainability requirements might be defined narrowly according to the goals of certain designers, users, organizations, policy-makers, society or the planet as a whole. Sustainability goals can also conflict. For example, designers, users and organizations may impose sustainability goals that address sustainability of the inner environment, like the organization’s stability and resilience. Further, the outer sustainability might restrict the available energy for the artifact, or limit its ability to transfer waste outputs; as a result there could be a loss of stability within the inner system.

4 A New Design Theory for Green IS

4.1 An Illustrative Empirical Case

In September 2015 the Volkswagen (VW) 'Dieselgate' [25] scandal broke loose. The US Environmental Protection Agency went public with the fact that they had found 'defeat' software embedded in diesel engines [26]. This piece of software was able to detect when a car was being tested, and then it could change the emission of Nitrogen Oxides NOx to the allowed level. In road-tests, however, the emission of NOx was up to 40 times higher [26].

The green perspective in this case is about NOx. According to GreenFacts [27] NOx can decrease lung function and increase the risk of respiratory symptoms such as acute bronchitis, cough and phlegm especially for children. Furthermore, one of the nitrogen oxides namely NO2 is a trace gas in the atmosphere that absorb the terrestrial radiation leaving the surface of the Earth [28]. Thus high levels of NOx contribute to the 'greenhouse effect'.

When the story broke it was a hot topic for weeks in newspapers all over the world. The International Federation of Information Processing – IFIP – brought a new perspective to the table focusing on the designers or developers. They said in a media release [25]:

> *"ICT professionals must operate according to a Code of Ethics and should be willing to challenge or even report any order from management that risks the safety of that organization's customers or staff. DieselGate is as much an indictment of the software industry as it is of the VW executives who issued the order for the software to be installed …"*

And IFIP went on to state that they saw it as going against professional practice and they pointed to the Milan Declaration [29] for a definition of that practice.

It is easy to see that in this case there are several stakeholders with different perspectives on the question of a sustainable systems design. There is the EPA representing the common opinion that we must reduce the outlet of NOx from cars for health-reasons. There is society-at-large interested in avoiding global warming. There is IFIP that wants to foster a professional profession. There is the carmaker VW that wants to sell cars. And then there are the many users or buyers of the cars. Thus one thing to take into account is the multitude of *stakeholders*.

The last mentioned stakeholder was the user. The question here is how should they participate?

User participation can be defined as "participation in the system development process by potential users or their representatives" [30, p. 53]. Traditionally user participation has been found to be a major factor in systems' success but there is no clear agreement on the benefits of user participation [31]. One explanation may be that user participation varies within each stage of the development process [32]. Thus the second issue is who is the user and how can we involve them?

If we now go back to the Dieselgate case we can find an announcement by VW from November 25 where they say they will "… install a small tubular part into some of its engines to help them come into line with European clean air standards" [33]. However, in US"… the E.P.A. said it wants to make sure that VW's fix will be effective before ordering a recall. To do so, the agency wants to be able to test diesel cars in its own laboratory and during on-road testing …" [33]. These two cites brings in a third dimension; the environment. Europe vs US at one level. Laboratory testing vs. Road testing at another level. Sustaining an economic versus ecological environment at a third level.

As soon as we talk about sustainability or Green IS we need to define; in relation to what environment? We could of course demand that one always took into account the 17 sustainable development goals by the United Nations http://www.un.org/sustainabledevelopment/sustainable-development-goals/ but that would hardly be doable in practice just because of the large number of goals to take into account. Hueting and Reijnders [34, p. 252], for example, discuss goal conflicts and call it "scarcely conceivable for the whole spectrum …". And they continue saying that "Especially, simultaneously realising both … production growth and conservation of the environment, is difficult". Hence, goals may be conflicting, less relevant, and have different importance for different stakeholders. Thus the fourth thing to take into account is sustainability and the relevant environment.

4.2 What Must Green IS Do and How?

Assuming that stakeholders, users, environment and sustainability definitions are given, we can then examine how IS can be designed that can allow organizations and individuals to perform environmentally sustainable work practices and make environmentally sustainable decisions.

Recker [9] argued that IS that are labelled "Green IS" must provide function to support belief formation, action formation and/or outcome assessment as they relate to environmental sustainability. Belief formation captures how psychic states (beliefs, desires, opportunities, etc.) about the natural environment are formed. Action formation describes how psychic states about the natural environment translate to actions that impact the environment. Outcomes describe what the consequences of the actions are. Each of these functions can operate at an individual level, or at an organizational level or both. Recker [9] suggests that an answer to how Green IS can provide functionality lies in examining how information systems provide functional affordances [35], viz., action potentials to users.

Affordances describe the possibilities for goal-oriented action afforded to specified user groups by technical objects such as information systems [35]. They emerge from material properties existent in information systems but emerge at the interaction between user and artifact. Thus, affordances have to be perceived before they can be actualized, and perceiving an affordance does not necessarily mean that users actually realize the offered action possibility [36].

With these notions in mind, we can delineate how Green IS can be built that afford action potential to belief formation, action formation and/or outcome assessment as they relate to environmental sustainability.

4.3 How Should Green IS Be Designed?

In identifying principles that can guide the development of "true" IS for environmental sustainability on the basis of our arguments above, we took inspiration from the Action Design Research (ADR) methodology [37] that is prominent in design science research, a research paradigm attempting to develop and evaluate new technology to address practical problems or goals [38]. We deemed the ADR methodology relevant and applicable because it provides emphasis for development of generalised theory and its focus on the blend of design and action research is fundamental to our emphasis on understanding the empirical domains of stakeholders, users and environment in the development of a Green IS.

Our view of the design principles for Green IS is visualized in Fig. 1. Therein, the eight principles are broadly classified into three of the four core stages of the ADR methodology, (1) problem formulation, (2) building, intervention, and evaluation (viz., design), and (3) reflection and learning (viz., theorizing). We omitted the fourth ADR stage, formalization of learning, because this stage centred on generalization and the meta-level design. We explain each principle in turn.

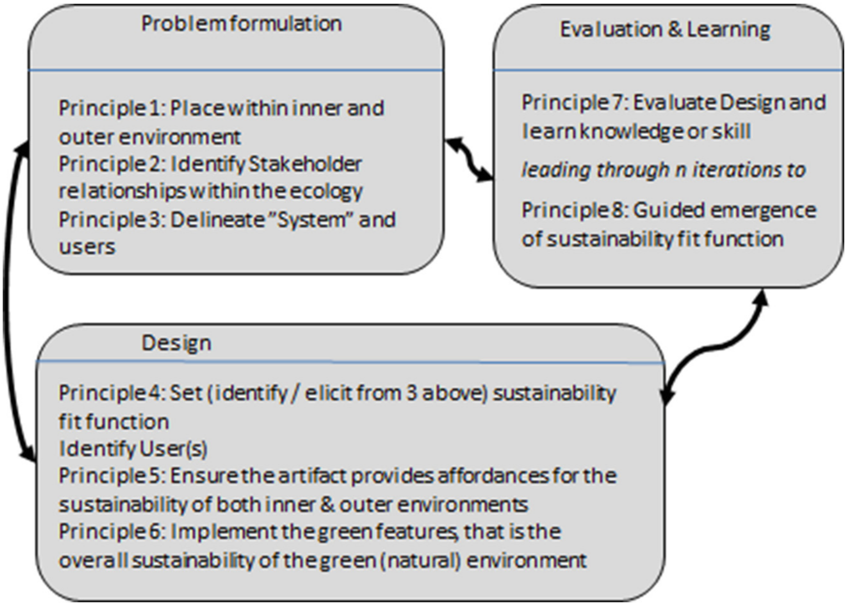

Fig. 1. Design principles for Green IS

Principle 1: Above we have argued that there is a generic requirement that designers make accommodations for the environment in which the designed artefact will operate. In Simon's terms, this is the external interface design of the artefact, such that the environment and the artefact match according to the purpose at hand. For the purpose of our generic approach, it means matching the IS design to the constraints and affordances that are delivered intrinsically by the environment in which the IS stakeholders and users will operate. In terms of design theory, this requirement embodies a specific capability of designers. That is, designers must be able to accommodate the environment.

Principle 2: To identify relevant affordances that must emerge from the relevant stakeholders' interaction with an artefact, it is important to understand their relationship with the ecology, in particular in terms of their goals and abilities.

Principle 3: Delineating the "System" and the "Users" is critical for distinguishing the artefact from its environment. The distinction may be as simple as defining the system as a software driven computing artefact. Such a distinction places the users in the artifact's outer environment, and pushes the social aspects of the ecology across the artifact's interface and out of the inner environment. Alternatively, the users can be regarded as part of the system. Such a distinction places the users within the artifact's inner environment and pulls the social aspects of the ecology across the artifact's interface and into the inner environment.

Principle 4: Once the interface has been delineated, designers can derive the sustainability fit functions for inner environmental sustainability and outer environmental sustainability based on definition of system, environments and user. These sustainability fit functions must incorporate environmental stability factors.

Principle 5: Based on the sustainability fit functions, designers can ensure that the artefact provides proper affordances for the sustainability of both inner & outer environments given the user. Where environments exhibit instability, the affordances must deliver qualities of resilience to both inner and outer environments. In addressing the outer environment, these sustainability affordances will include features that support sustainability of the green ecology.

Principle 6: Sustainability fit functions enable designs that can prioritize the green features. With green sustainability affordances based on the sustainability fit functions, the overall sustainability of the identified (natural) ecology can be given proper priority in the design.

Principle 7: Iteration of the appropriate design science evaluate-and-learn cycle supports refinement and improvement of satisfactory green IS designs. Evaluation covers the judgement or determination of the significance, worth, or quality of the design. Learning covers the acquisition of knowledge or skills throughout the iteration.

Principle 8: Green IS Designs occur in continuing iterations of problem formulation, design, and evaluation/learning that maintain the natural ecological sustainability fit functions as a centrepiece in the design-redesign process. Green IS design is a process of sustainability-guided emergence.

5 Conclusion

In this paper we contributed a design theory for Green IS that builds on a careful definition of the relevant concepts of stakeholders, system, environment and sustainability. We described our theory in terms of eight novel design principles. Importantly, the class of systems characterized by our design theory has explicit goals of affording environmentally sustainable practices and decisions to users. It allows designer to specify and implement systems that are true to the label "Green IS". With this explicit focus and its requirements, systems in our theory differ from others that are also associated with being "green". Notably, we prescribe that "Green IS" systems must adhere to the requirements set out in this paper.

We note several limitations. First, our research is on the level of theoretical rules and predictions. The development of an expository instantiation and an empirical evaluation of the design principles remains to be completed. Second, much like most other Green IS research we remained focus on the environmental dimension sustainability without regarding interaction effects to other dimensions (e.g., economic or social goals). Still, we believe our research provides a substantial and original contribution to design knowledge in green IS, which has been notably absent to date [2, 10]. Our theory allows both for prescriptiveness and guidance for action as well as for discrimination and identification of boundary conditions. Both is useful in progressing Green IS research because we provide assertions for testing and falsification as well as rules that can delineate the boundaries of the entire field.

References

1. Gadatsch, A.: Comments on "Green IT: a matter of business and information systems engineering?''. Bus. Inf. Syst. Eng. **3**(6), 397 (2011)
2. Watson, R.T., Boudreau, M.-C., Chen, A.J.: Information systems and environmentally sustainable development: energy informatics and new directions for the IS community. MIS Q. **34**(1), 23–38 (2010)
3. Elliot, S.: Transdisciplinary perspectives on environmental sustainability: a resource base and framework for IT-enabled business transformation. MIS Q. **35**(1), 197–236 (2011)
4. Melville, N.P.: Information systems innovation for environmental sustainability. MIS Q. **34**(1), 1–21 (2010)
5. Seidel, S., Recker, J., vom Brocke, J.: Sensemaking and sustainable practicing: functional affordances of information systems in green transformations. MIS Q. **37**(4), 1275–1299 (2013)
6. Brewer, R.S., Johnson, P.M.: WattDepot: an open source software ecosystem for enterprise-scale energy data collection, storage, analysis, and visualization. In: 1st IEEE International Conference on Smart Grid Communications 2010, Gaithersburg, Maryland. IEEE, pp. 91–95 (2010)
7. Hilpert, H., Schumann, M., Kranz, J.: Leveraging Green IS in logistics: developing an artifact for greenhouse gas emission tracking. Bus. Inf. Syst. Eng. **5**(5), 315–325 (2013)
8. Shi, P., et al.: A decision support system to select suppliers for a sustainable supply chain based on a systematic DEA approach. Inf. Technol. Manag. **16**(1), 39–49 (2015)

9. Recker, J.: Toward a design theory for green information systems. In: 49th Hawaiian International Conference on Systems Sciences 2016, Kuaui, Hawaii. IEEE (2016)
10. Malhotra, A., Melville, N.P., Watson, R.T.: Spurring impactful research on information systems for environmental sustainability. MIS Q. **37**(4), 1265–1274 (2013)
11. Molla, A., Cooper, V., Pittayachawan, S.: The Green IT readiness (G-Readiness) of organizations: an exploratory analysis of a construct and instrument. Commun. Assoc. Inf. Syst. **29**(4), 67–96 (2011)
12. Chen, A.J., et al.: An institutional perspective on the adoption of Green IS & IT. Australas. J. Inf. Syst. **17**(1), 5–27 (2011)
13. Butler, T.: Compliance with institutional imperatives on environmental sustainability: building theory on the role of Green IS. J. Strateg. Inf. Syst. **20**(1), 6–26 (2011)
14. Hilpert, H., Kranz, J., Schumann, M.: An Information system design theory for green information systems for sustainability reporting - integrating theory with evidence from multiple case studies. In: 22th European Conference on Information Systems 2014, Tel Aviv, Israel. Association for Information Systems (2014)
15. Reuter, N., et al.: Identifying the role of information systems in achieving energy-related environmental sustainability using text mining. In: 22th European Conference on Information Systems 2014, Tel Aviv, Israel. Association for Information Systems (2014)
16. Simon, H.A.: The Sciences of the Artificial, 3rd edn. MIT Press, Cambridge (1996). p. 247
17. Klir, G.: Facets of Systems Science. IFSR International Series on Systems Science and Engineering, 2nd edn. Springer, New York (2001)
18. Bødker, K., Bansler, J.: A reappraisal of structured analysis: design in an organizational context. ACM Trans. Inf. Syst. (TOIS) **11**(2), 165–193 (1993)
19. Fitzgerald, B.: Systems development methodologies: the problem of tenses. Inf. Technol. People **13**(2), 13–22 (2000)
20. Wynekoop, J.L., Russo, N.: Studying system development methodologies: an examination of research methods. Inf. Syst. J. **7**(1), 47–65 (1997)
21. Truex, D., Baskerville, R., Travis, J.: Amethodical systems development: the deferred meaning of systems development methods. Acc. Manag. Inf. Technol. **10**, 53–79 (2000)
22. Chen, A.J.W., Boudreau, M.-C., Watson, R.T.: Information systems and ecological sustainability. J. Syst. Inf. Technol. **10**(3), 186–201 (2008)
23. Frova, G.: Five decades of development debate on sustainability. Development **54**(2), 271–281 (2011)
24. Holling, C.S.: Resilience and stability of ecological systems. Annu. Rev. Ecol. Syst. **4**(1), 1–23 (1973)
25. IFIP. IFIP IP3 Denounces Actions of Technologists Who Enabled VW DieselGate Scandal. IFIP News 2015, 8 October 2015. http://www.ifipnews.org/ifip-ip3-denounces-actions-of-technologists-who-enabled-vw-dieselgate-scandal/
26. Holten, R: Volkswagen: the scandal explained (2015). http://www.bbc.com/news/business-34324772. (cited 2016 15 February)
27. GreenFacts. Air Pollution Nitrogen Dioxide (2016). http://www.greenfacts.org/en/nitrogen-dioxide-no2/index.htm#1. (cited 2016 15 February)
28. IPCC, Climate Change 2013: The Physical Science Basis. In: Stocker, T.F., Qin, D. (eds.) Intergovernmental Panel on Climate Change (2013)
29. IFIP, WCC 2008 Declaration on ICT Professionalism and Competences, T.I.P.P.P.I. IP3, a project of the International Federation for Information Processing (IFIP), Editor 2008, Milan, Italy (2008)
30. Barki, H., Hartwick, J.: Rethinking the concept of user involvement. MIS Q. **13**(1), 55–63 (1989)

31. Ives, B., Olson, M.H.: User involvement in MIS success: a review of research. Manag. Sci. **30**(5), 586–603 (1984)
32. Newman, M., Noble, F.: User involvement as an interaction process: a case study. Inf. Syst. Res. **1**(1), 89–113 (1990)
33. Russel, K., et al.: How Volkswagen Got Away With Diesel Deception in New York Times (2016)
34. Hueting, R., Reijnders, L.: Broad sustainability contra sustainability: the proper construction of sustainability indicators. Ecol. Econ. **50**(3), 249–260 (2004)
35. Markus, M.L., Silver, M.S.: A foundation for the study of IT effects: a new look at DeSanctis and Poole's Concepts of structural features and spirit. J. Assoc. Inf. Syst. **9**(10), 609–632 (2008)
36. Stoffregen, T.A.: Affordances as properties of the animal-environment system. Ecol. Psychol. **15**(2), 115–134 (2003)
37. Sein, M.K., et al.: Action design research. MIS Q. **35**(2), 37–56 (2011)
38. Gregor, S., Hevner, A.R.: Positioning and presenting design science research for maximum impact. MIS Q. **37**(2), 337–355 (2013)

http://www.springer.com/978-3-319-44446-8

ICT for Promoting Human Development and Protecting the Environment
6th IFIP World Information Technology Forum, WITFOR 2016, San José, Costa Rica, September 12-14, 2016, Proceedings
Mata, F.; Pont, A. (Eds.)
2016, XIII, 245 p. 42 illus., Hardcover
ISBN: 978-3-319-44446-8