A Systematic Review of Sustainability and Aspects of Human-Computer Interaction

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Abstract. Sustainability is the term employed for the practice of ensuring that goods and services are produced in ways that do not use resources that cannot be replaced. This practice has been in focus on several different research agendas. In the area of Human-Computer Interaction, studies devoted to works investigating this matter began to appear eight years ago. It is a timely moment to look back and see how much the community has achieved. This paper provides the results of a Systematic Review carried out in four scientific databases. The selected papers were grouped considering the topics they present, the methodological approach adopted and the kind of outcomes that emerged. The results suggest that among the different methodological approaches adopted, literature reviews and criticism still form the main basis to underpin the outcomes. Moreover, climate change and energy savings were found to be the specific areas that were most researched. The results obtained make it possible to suggest opportunities for further research.

Keywords: Sustainability, Systematic Review, Human-Computer Interaction.

1 Introduction

Sustainability is the term employed for the practice of ensuring that goods and services are produced in ways that do not use resources that cannot be replaced. Its application entails defining human practices in a way that prevents our needs from causing harm to future generations. Sustainability is currently an issue of global concern and has thus been highlighted in several different research agendas.

As well as being concerned with environmental factors, regarding the adoption of measures that do not degrade the environment, (for example a reduction in fossil fuel consumption), the concept of sustainability also involves social and economic issues. The social questions concern human rights, respect for differences and the spread of values that support the maintenance of society for future generations. The economic questions involve taking measures that are financially viable, yield a profit and support income distribution.

Computers play a central role in sustainability issues. On the one hand, computers are increasingly present in daily life and allow the dissemination of information on a

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large scale. They can thus be used as a tool for awareness, mobilization and the encouragement of behavioral changes in favor of sustainability. On the other hand, computing solutions, which include both hardware and software, are a commodity and hence affect sustainability issues, and require new ideas about our design, developmental policies and consumer practices.

Some large companies have already begun developing hardware solutions that require less energy, reduce the amount of heavy materials or use recyclable materials in their manufacture, such as PET bottles. In the implementation of software, there has also been the development of open source solutions, architectures that facilitate the reuse of software and technical data storage that uses less memory, to name a few.

Researchers in the field of Human-Computer Interaction (HCI) have pondered on this issue. Studies that were devoted to this issue began to appear eight years ago. Since then, there has been an increase in the number of HCI researchers concerned with this issue; workshops have been set up and meetings held to discuss it. In his summary, Blevis [1] states that research into HCI can assist in two key complementary areas: (i) sustainability through design or, as we prefer to call it, design for sustainability, i.e. how interactive systems can lead to more sustainable behavior, such as games that teach the principles of sustainability or clothing that interacts with nature by fostering environmental awareness and (ii) sustainability in design, i.e. how sustainability can be used as a critical lens to reveal the design of interactive technologies themselves.

In this paper, we examine the results of a Systematic Review (SR) which was carried out to determine how the HCI community has contributed to research into the question of sustainability. Four databases of scientific knowledge were examined: ACM, IEEE, Scopus and Google Scholar. The searches returned 200 papers, and after the exclusion criteria defined in the SR protocol were applied, 51 were chosen to represent the research that has been carried out in HCI with a focus on sustainability. The selected papers were grouped considering the topics they present, the methodological approach adopted and the different types of outcomes. In the light of the SR results, seven key groups for analysis have emerged: a)Design for Sustainability, b)Sustainability in Design, c)Living with Technology, d) Specific topics including climate change, peace, feminism, energy saving and hunger, e)Methodological aspects and approaches, f) Persuasion and g) Implications for Design.

The paper is structured as follows: Section 2 clarifies the concept of sustainability; Section 3 describes how the SR was carried out in this work; Section 4 outlines the chosen papers according to the formed groups; Section 5 conducts a critical analysis; and Section 6 summarizes the conclusions and draws attention to gaps in the research.

2 The Concept of Sustainability

In 1987, the Norwegian chairman of the World Commission on Environment and Development (WCED) of the United Nations, Gro Harlem Brundtland, issued the report "*Our Common Future*". In this he argued that humanity is capable of an appropriate development to meet the needs of the present without adversely affecting the needs of future generations. This report also seeks to reconcile economic growth with environmental issues and thus attain a balanced development. The combination of

three pillars (social, economic and environmental), gives rise to a database that can be analyzed to ensure that a practice is sustainable.

The environmental pillar concerns all the wealth that sustains natural ecosystems and the benefits that they produce, including the flora, fauna and all the products derived thereof. The social pillar addresses the question of human rights, but also includes broader measures of health and education that can ensure the continuity of life in society. The economic pillar is linked to profit. Its main objective is to analyze questions such as the return on investments, market share, profitable activities that increase the return on investment for shareholders and increasing business growth [2].

3 The Research Approach

An SR is a research technique that aims to carry out an evaluation of a research question, by employing a review methodology that is reliable, accurate and allows auditing [3]. This technique involves gathering and collating a large amount of research data, answering research questions that have been previously defined and using systematic and clear methods to identify, select and critically evaluate research material [4]. The SR carried out in this work seeks to help the authors to determine how the HCI community has conducted research by examining the question of sustainability. The application of this technique occurs in three phases: Planning, Execution and Results Analysis [3].

3.1 Planning

Planning is designed to determine the research objectives, the way in which the SR will be carried out and which criteria will be applied to the studies [3]. The main purpose of this investigation is to examine works that show the state- of- the- art in HCI research on sustainability.

The research questions defined for this work are as follows: Q1) What topics in Sustainability and HCI have been addressed by researchers? Q2) What methodological approaches have been adopted? and Q3) What outcomes have been formalized, especially those which support the design?

Four databases were used for the analysis and selection of primary studies: IEEE, ACM, Google Academic and Scopus. The Papers had to be written in English. The following inclusion criteria were chosen to provide guidelines for each of the research questions: I1 - The work should address the sustainability issue; I2 - The work must be related to IT; I3 - The work should approach aspects of HCI. Exclusion criteria were defined to refine the search, find works that were appropriate for the context and address the research questions. These criteria are as follows: E1 - The work does not take account of aspects of IHC; E2 - The work is not related to IT; E3 - The work does not address issues related to sustainability; E4 - The work is not available on the Internet; E5 – The work has the same author(s), results and methodological approach as that of another paper which is already included.

3.2 Execution

The SR was carried out over a period of 4 months. The search string defined was:

((“Sustainable Interaction Design”) OR ((design) AND (HCI) AND (sustainability)))

The searches in the Google Academic database returned 73 works. The ACM database returned 48 works, the Scopus database returned 56 works and the IEEE database returned 23 works, making a total of 200 related works. After the exclusion criteria were applied, 51 papers were chosen to represent the research that has been carried out in HCI with a focus on sustainability.

3.3 Results Analysis

Following the objectives of this systematic review, 51 key primary studies were read again and classified according to the main issue or problem investigated. The methodological approach and the outcomes were analyzed in a way that took account of the implications for the design. Figure 1 illustrates the main phases of this SR.

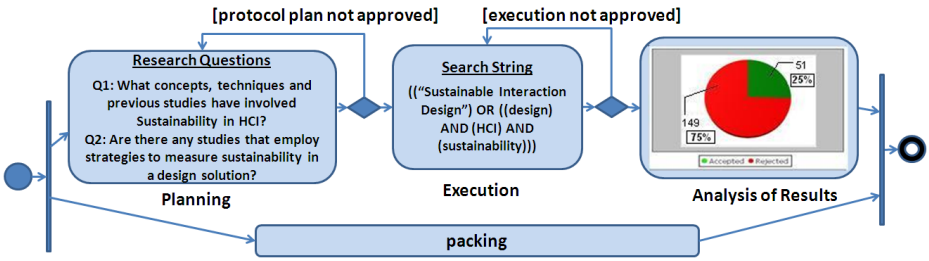

Fig. 1. Instantiation of SR. Source: [3] adapted.

4 Sustainability and HCI

After studying the 51selected papers, seven major thematic groups emerged. These are: a) Design for Sustainability, b) Sustainability in Design, c) Living with Technology, d) Specific Topics including climate change, peace, feminism, energy saving and hunger e) Methodological factors and approaches, f) Persuasion and g) Implications of SR for Design.

4.1 Design for Sustainability

This group is concerned with studies on how to design software and hardware that fosters or supports sustainability and/or a more sustainable behavior in humans. In other papers, this is called sustainability through design. The papers conduct investigations mainly into human behavior, design principles and software systems.

[5], [6], [7], [8] investigate people’s attitudes and critical thinking about sustainable practices. [9] and [10] argue in favor of supporting the collective and collaborative aspects of sustainability. In [11] and [12], Piccolo and Baranauskas explore motivational

factors. [13] analyses the complexity of sustainable choices and emphasizes the need for simplicity and reliable information. [14] and [15] defend flexible and adaptive informatics, to deal with a possible world collapse.

In [1], Blevis sets out several principles to guide Sustainable Interaction Design and in [16], Wakkary and Tanenbaum give examples of Blevis' principles and expand the concept of the user, as forming a part of a sustainable identity. [17] analyses a set of design techniques that can be used to support design for sustainability. Pereira et al. [18] argue in favor of sustainability as a value for the design of software applications. [19] illustrates some model design concepts that are related to sustainability and [20] give an overview of the research approaches adopted in Information Technology and sustainability.

The design of software systems is discussed in several papers. [21] outlines an eco-feedback system and [12] describes a residential energy feedback system. [22] carried out routines to keep computer machines off for a longer time. [23] discusses sustainable factors in an environmental management system. Sourcemap [24] represents sustainability factors in supply chains and the Climate Change Habitability Index [25] presets diagrams of climate change. Coralog and Timelog [26] are systems to ambient displays that represent metrics of sustainability.

[27], [28], [29], [30], [31], [32], [33], [34] and [35] are proposals for events, mainly workshops, which summarize some theoretical basis and raise research challenges in the design for sustainability.

4.2 Sustainability in Design

This group undertakes research that takes account of social, economic and environmental issues in our own design, implementation and/or evaluation practices. Although Mankoff et al. [34] stress the need for research on this area; from the works returned in the SR, only [36] treats this question as a central issue. Mann et al.[36] underline the need for the invisible to be made visible in a sustainable approach to software development, as well as he need to think about scalability.

However, it is possible to highlight some features of the returned papers that can be explored in greater depth to improve sustainability in the design. [21] and [22] investigate attitudes regarding the reduction of the energy consumption of the computerized machines which are used in our daily professional practices. Issues of collaboration [9], information complexity [13] and (un)sustainable materials [5] can be explored for the design process. [16], examines the question from the perspective of a sustainable identity, and discusses some possible sustainable design features from the user to the designer. [19] explores the prospect of applying pedagogical practices in design courses to prepare professionals for sustainability in design as well. In [37], Arieff and Casey discuss the role of designers in sustainability and also encourage changes in design firms.

4.3 Living with Technology

The studies on this question are concerned with fashion consumption. [38] and [39] discuss the role of fashion and luxury when a customer is choosing personal electronic devices. The main idea in these papers is that if we can better understand how fashion

affects consumer attitudes and behavior, we may be able to use fashion as a positive force for changing behavior with regard to sustainability. Especially in the digital domain, fashion can persuade people to adopt new technologies or new devices. This can lead to premature technological obsolescence and raises the question of what to do with so many devices that are left unused or needlessly disposed of for reasons of fashion and consumption. [1], [13] and [40] discuss the concept of reuse of devices.

4.4 Specific Topics

Since it is a multidisciplinary area, HCI can address different aspects of sustainability. This category examines some specific topics that appeared in the SR:

Hunger. According to [41], one imminent consequence of global warming is its effect on food supply, which is the basis of human sustenance. Essentially, sustainability in this sense is concerned with "securing" food: ensuring supplies are stable and available and that the food is of an acceptable quality. In helping to encourage the sustainable use of food, Blevis and Morse [42] propose a set of practices such as the "monitoring of food" - interactive technologies can trace the origin of food, and provide information that can ensure that that the food is organic or has "sensors for gardens" - which can be linked to computer applications that provide advice on what can be planted and when, and other useful information.

Energy Saving. The works related to this category focus on areas that can assist in the reduction of energy consumption by outlining new technologies that foster awareness among users and encourage them to change their behavior. [11], [12], [21] and [22] provide eco-feedback systems, which are interactive devices that reveal energy use. In [43], Froehlich maps ten design dimensions for feedback systems. In [44], the focus is on designing strategies for eco-visualizations by "offering behavioral cues as indicators".

Peace. Hourcade et al. [45] propose combining other disciplines in researching the areas of peace and human conflict. Subjects such as neurology, political science, behavioral economics, and sociology should be included to support the development of interactive technologies. The advent of Internet connectivity, mobile devices and social media, provides a powerful cocktail that allows computing and HCI to be key components in peaceful change, at both an individual and social level.

Feminism. Bardzell and Blevis [46] suggest researchers to think differently about gender lead, considering, for example, to conduct user research in a way that is sensitive to gender-identity practices i.e. when interacting with users, one should be mindful of the cultural conventions of gender, and focus user research acknowledging different standpoints and experiences.

Climate Change. [24] proposes a carbon footprint calculator that measures each life stage of a product: raw material extraction, production, transport of goods, use and end-of-life. [25] shows diagrams to enable ordinary individuals to understand the state of the world in terms of habitability at particular places, in the face of climate change. In [14],

Tomlinson et al. consider the possibility of an imminent global change, mainly caused by climate change, and emphasize the need for HCI research in crisis scenarios. [47] speculates on some actions that the interaction design community can take to "prepare for the worst".

4.5 Persuasion

It is apparent that most of the works on sustainability seek to educate people and persuade them to make changes in their daily-life practices. By analyzing environmental discourses in papers about sustainability, [48] classifies the design of persuasive applications as a key objective.

In [22], Hanks et al. see a behavioral change in IT professionals regarding energy savings, through the GoGreen sidebar gadget. They have made use of mass email services to inform people about the changes and provide other communication tools to report problems and disseminate instructions. Kim et al. [26] analyze the effects of Coralog and Timelog on fifty-two participants. The results suggest that ambient displays can help bring about alterations in behavior.

Piccolo and Baranauskas [11] study motivational factors and one of the design strategies outlined in their study relies on credibility as a key factor in the persuasiveness of energy feedback systems. In [49], the same authors provided evidence of a lack of intrinsic motivation for people to make savings in the consumption of electricity. [41] proposes a design framework to encourage a sustainable food culture in urban environments. They examine behavioral changes through engagement, which they believe should take account of people, places and technology. In [50], DiSalvo et al. highlight the need for a debate regarding sustainability and HCI and point out concerns about ethical issues when persuasion begins to border on coercion.

4.6 Methodological Aspects and Approaches

This section aims to answer the second question defined in the SR and the studies have been grouped considering the main methodological approach they mentioned. Interviews were conducted in [38] with a sample of 30 participants to assess their consumer behavior. Odom [40] carried out 22 in-home contextual interviews and [13] interviewed 11 people about the complexity of information. Surveys were undertaken in [5] with 435 participants who gave their opinions about the material effects of information technologies. In Australia, 216 business men took part in a survey on their attitudes toward environmental issues [23]. In [49], 280 participants were involved in a structured interview about the reasons to save energy.

Case studies were undertaken with 4 families to find out about sustainable everyday design practices [16]. [7] investigated the motivating factors, practices and experiences of 35 environmentally responsible households. [39] analyses design decisions in several technologies and [51] design decisions regarding technology in several places. [10] studied the deployment of PreHeat, a home heating system, in 5 homes in USA and 2 in UK. A participatory design was introduced with students for a residential energy feedback system [12], and [8] records some participatory practices with 19 residents of an eco-house college with "ethnographically-inspired" methods. Organizational Semiotics was applied as a theoretical reference in [11] and Goodman [48] employed a discourse analysis technique in 3 different literature sources.

User tests were performed with an eco-feedback system [21], and the GoGreen gadget [22]. [26] conducted online surveys, analyzed logs in a period of two weeks and held semi-structured interviews with users of Coralog. [24] supplies some data on the use of Sourcemap in different situations. Several other papers employed literature reviews and/or criticism as their main methodological approach such as [1], [6], [9], [14], [17], [18], [20], [36] [41], [43], [44], [45], [47], [50], [52], [53] and [54].

4.7 Implications for Design

This section attempts to answer the third question in the SR and the papers were grouped considering the main implications for the design they formalized. We did our best to keep the terms as those adopted by the authors. Requirements were set in a few papers. In [11], they include, for example, publish global results of individual attitudes to motivate users. In [26], there are design requirements for persuasion and in [49], there are requirements for residential eco-feedback systems. [5] classifies four personal profiles for sustainable use and discusses some strategies to deal with them.

Principles were formalized in [1] and consisted of linking invention and disposal, and promoting renewal and reuse. In [16], there are principles for design-in-use. In [40], the principles include symbolism, material qualities, engagement and augmentation among others. [52] defines several principles for sustainable design that are based on social theories. Some speculations for design are made in [38] and for research questions as pointed out on [47]. Singhal [17] speculates on how some methods and techniques can be employed for eco-feedback technology.

Sohn and Nam [6] formalize a framework based on four attributes of unconscious everyday human behavior. [39] proposes an informal design critical framework for luxury and sustainability. [19] establishes a framework for teaching strategy design planning which can include sustainability concerns in the design. Pereira et al. [18] postulate sustainability as a value for design and [14] emphasizes the need for adaptation in technology. Froehlich [43] defines ten design dimensions for feedback systems, including data granularity and social sharing. [7] defines design directions which include encouraging individuals to make personal choices and identity expression. Key points [41] and lessons for sustainable design, with an emphasis on collaboration [9] were also formalized. Goodman [48] recommends participatory design and moving beyond human-centered computing as promising directions for future work.

5 Critical Analysis

The information obtained from the SR was plotted in a Bubble Chart with two quadrants [55], as illustrated in Figure 2. In the first quadrant (left), there is information about the groups (classification) and the amount of works in each of them per year. It should be noted, for example, that in 2011 we detected 8 works classified in the Design for Sustainability group, 3 works in Sustainability in Design and so forth. The studies can be labeled in more than one classification.

In the second quadrant (right), the studies for each group were classified in accordance with the methodology used. It was possible to notice that 7 different kinds of methodologies were employed in the collected works. These are as follows: user tests,

literature review and/or criticism, case studies, discourse analysis, surveys, participatory design and interviews. In Specific Topics, for example, 6 studies were considered as forming a Literature Review/Criticism. Some studies used more than one type of methodology or assessment instruments, and thus, were also classified in more than one methodology in the chart above.

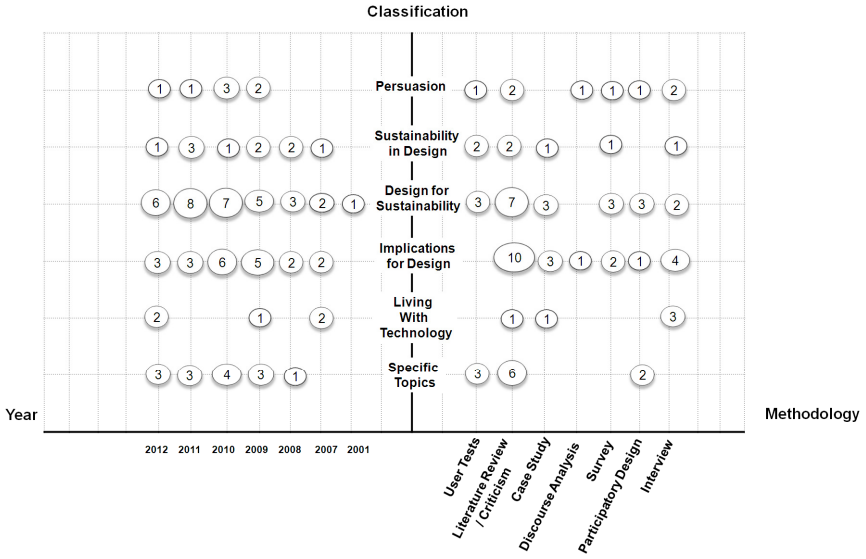

Fig. 2. Distribution of works about sustainability and HCI over the years and the main methodologies employed. Numbers in the balls represent quantity of works.

From Figure 2, it can be observed that there was an "upsurge" in the volume of works on sustainability from 2010 onwards. However, apart from that, there has been a progression of works over the years which suggests that the authors in this area have consistently been publishing new papers. We also observed that most of the studies, in most of the classifications, have adopted literature reviews and pure criticism. This applies, for example, to the works classified in the 'Implications for Design' category. Although this category contains several works, few of them provide guidelines or specifications for design which have been validated with users.

6 Conclusion

Research on how we can live in a sustainable manner is essential for future generations. Computers play a central role in this issue, and hence, the HCI area can contribute to research that addresses this complex issue. In the last seven years, several important achievements have been made by the HCI community with regard to sustainability, and a few research groups have been focusing on different issues.

In the light of the results of the SR, some gaps in research can be detected, or in other words, there are research opportunities with regard to sustainability in the HCI.

These include the following: (1) Other methodological approaches can be used to support the outcomes, including long-term studies and ethnography. (2) The users should be included in different stages of the design process, not only when requirements are being elicited (mainly through questionnaires). Participatory design or action-research can be more employed. (3) Research on specific (and important) topics such as peace and hunger need interdisciplinary and intercultural collaboration. Geographically-separated research groups can be formed. (4) The solutions generally take account or the environmental, or the social or the economic aspect of sustainability. Until now, few studies have examined two of them in combination. Research on sustainability should focus on the three pillars together. (5) We need to rethink our design practices in the light of sustainability and create artifacts, tools, techniques, models etc, which can support both the design for sustainability and sustainability in the design.

References

1. Blevis, E.: Sustainable interaction design: invention & disposal, renewal & reuse. In: Proceedings of the SIGCHI 2007. ACM, New York (2007)
2. Estender, A., Pitta, C., Moreira, T.T.O.: Concept of Sustainable Development - The Third Sector (2008) (in Portuguese), http://revistas.ung.br/ (accessed on: September 2012)
3. Kitchenham, B.: Procedures for Performing Systematic Reviews. Technical Report, TR/SE-0401, Australian (2004) ISSN: 1353-7776
4. Clarke, M., Oxman, A.D.: Cochrane Reviewers' Handbook 4.1; Section 7. In: Review Manager (RevMan) [Computer program]. The Cochrane Collaboration (2001), http://www.cochrane.dk/cochrane/handbook/handbook.htm (accessed on: November 2012)
5. Hanks, K., et al.: Sustainable millennial: attitudes towards sustainability and the material effects of interactive technologies. In: Proceedings of the CHI 2008. ACM, New York (2008)
6. Sohn, M., Nam, T.: Design Method for Sustainable Interaction. In: Proceeding of the IASDR 2009 (2009)
7. Woodruff, A., Hasbrouck, J., Augustin, S.: A bright green perspective on sustainable choices. In: Proceedings of the CHI 2008. ACM, New York (2008)
8. Davis, J.: Participatory design for sustainable campus living. In: Proceedings of the CHI 2010. ACM, New York (2010)
9. Mann, S., Smith, L.: Collaboration in sustainability vision. In: International Conference on Collaboration Technologies and Systems (CTS) (2011)
10. Hazas, M., Brush, A.J.B., Scott, J.: Sustainability does not begin with the individual. Interactions 19(5), 14–17 (2012)
11. Piccolo, L.S.G., Baranauskas, M.C.C.: Motivational aspects in energy feedback systems design. In: Proceedings of the IHC+CLIHC 2011 (2011)
12. Piccolo, L.S.G., Baranauskas, M.C.C.: Energy, environment, and conscious consumption: making connections through design. In: Proceedings of the IHC 2012 (2012)
13. Remy, C., Huang, E.M.: The Complexity of Information for Sustainable Choices. In: Proceedings of the CHI 2012, Austin, TX, USA, May 5-10 (2012)
14. Tomlinson, B., et al.: What if sustainability doesn't work out? Interactions 19(6), 50–55 (2012)

15. Tomlinson, B., et al.: Collapse informatics: augmenting the sustainability ICT4D discourse in HCI. In: Proceedings of the CHI 2012. ACM, New York (2012)
16. Wakkary, R., Tanenbaum, K.: A sustainable identity: the creativity of an everyday designer. In: Proceedings of the CHI 2009 (2009)
17. Singhal, H.: Eco-Feedback Technology: Road to Sustainability. In: Proceedings of Nordchi 2010, pp. 178–187. ACM, Iceland (2010)
18. Pereira, R., Lima, M., Baranauskas, M.C.C.: Sustainability as a value in technology design. In: Proceedings of the IWCSC 2010. ACM, New York (2010)
19. Blevis, E.: Designchallenge based learning (DCBL) and sustainable pedagogical practice. Interactions 17(3), 64–69 (2010)
20. Hilty, L., Lohmann, W., Huang, E.: Sustainability and ICT – An Overview of The Field. Notizie Di Politeia Xxvii, 104, 13–28 (2011) ISSN 1128-2401
21. Heras, D.B., Otero, D., Arguello, F.: An eco-feedback system for improving the sustainability performance of universities. In: Proceedings of the VECIMS 2011 (2011)
22. Hanks, K., et al.: SUSTAINABLY OURS: Small change, big result. Interactions 16(6), 24–27 (2009)
23. Wilmshurst, T.D., Frost, G.R.: The Climate Change. Business Strategy and the Environment 10(3), 135–147 (2001)
24. Bonanni, L.: Sourcemap: eco-design, sustainable supply chains, and radical transparency. XRDS 17(4), 22–26 (2011)
25. Pan, Y., Cheong, C.M., Blevis, E.: The climate change habitability index. Interactions 17(6), 29–33 (2010)
26. Kim, T., Hong, H., Magerko, B.: Design requirements for ambient display that supports sustainable lifestyle. In: Proceedings of the DIS 2010 (2010)
27. Haakansson, M., et al.: Simple, sustainable living. In: Proceedings of CHI 2012 Extended Abstracts on Human Factors in Computing Systems (2012)
28. Khan, A., et al.: Sustainability community invited panel: challenges ahead. In: CHI 2011 (2011)
29. Busse, D.K., et al.: Designing for a sustainable future. In: Proceedings of the Seventh ACM Conference on Creativity and Cognition. ACM, New York (2009)
30. Bonanni, L., et al.: Visible - actionable - sustainable: sustainable interaction design in professional domains. In: Proceedings of the CHI EA 2011 (2011)
31. Pierce, J., et al.: Everyday practice and sustainable HCI: understanding and learning from cultures of (un)sustainability. In: Proceedings of the CHI EA 2011, New York, NY, USA (2011)
32. Nathan, L.P., et al.: Beyond the hype: sustainability & HCI. In: Proceedings of the CHI 2008. ACM, New York (2008)
33. Huh, J., et al.: Examining appropriation, re-use, and maintenance for sustainability. In: Proceedings of the CHI 2010. ACM, New York (2010)
34. Mankoff, J.C., et al.: Environmental sustainability and interaction. In: Proceeding of the CHI 2007. ACM, New York (2007)
35. Huang, E.M., et al.: Defining the role of HCI in the challenges of sustainability. In: Proceedings of the CHI 2009. ACM, New York (2009)
36. Mann, S., Smith, L., McGregor, G.: A research framework for sustainable software. In: Proceedings of the CITRENZ 2011, CITRENZ, NZ, pp. 167–180 (2011)
37. Arieff, A., Casey, V.: (P) REVIEW: Merging design, Business, and sustainability: the designers accord. Interactions 15(3), 61–66 (2008)
38. Pan, Y., et al.: Re-conceptualizing fashion in sustainable HCI. In: Proceedings of the DIS (2012)

39. Blevis, E., et al.: Luxury & new luxury, quality & equality. In: Proceedings of the DPPI 2007. ACM, New York (2007)
40. Odom, W., et al.: Understanding why we preserve some things and discard others in the context of interaction design. In: Proceedings of the CHI 2009. ACM, New York (2009)
41. Choi, J.H., Blevis, E.: HCI & sustainable food culture: a design framework for engagement. In: Proceedings of the NordiCHI 2010. ACM, New York (2010)
42. Blevis, E., Morse, S.C.: Sustainably Ours: Food, dude. Interactions 16(2), 58–62 (2009)
43. Froehlich, J.: Promoting Energy Efficient Behaviors in the Home through Feedback: The Role of Human Computer Interaction. In: HCIC 2009, Winter Workshop (2009)
44. Pierce, J., Odom, W., Blevis, E.: Energy aware dwelling: a critical survey of interaction design for eco-visualizations. In: Proceedings of the OZCHI 2008. ACM, New York (2008)
45. Hourcade, J.P., et al.: HCI for peace: beyond tie dye. Interactions 19(5), 40–47 (2012)
46. Bardzell, S., Blevis, E.: The lens of feminist HCI in the context of sustainable interaction design. Interactions 17(2), 57–59 (2010)
47. Blevis, E., Blevis, S.: Hope for the best and prepare for the worst: interaction design and the tipping point. Interactions 17(5), 26–30 (2010)
48. Goodman, E.: Three environmental discourses in human-computer interaction. In: Proceedings of the CHI 2009. ACM, New York (2009)
49. Piccolo, L.S.G., Baranauskas, M.C.C.: Basis and prospects of motivation informing design: requirements for situated eco-feedback technology. In: Proceedings of the IHC 2012. Brazilian Computer Society, Porto Alegre (2012)
50. Disalvo, C., Sengers, P., Brynjarsdóttir, H.: Navigating the terrain of sustainable HCI. Interactions 17(4), 22–25 (2010)
51. Blevis, E., Blevis, S.: Sustainably Ours: Images of sustainable interactions: seeing with the lens of sustainability. Interactions 15(3), 27–29 (2008)
52. Fuchs, C.: HCI and Society: Towards a Typology of Universal Design Principles. International Journal of Human-Computer Interaction 26(6), 638–656 (2010)
53. Huang, E.M.: Building outwards from sustainable HCI. Interactions 18(3), 14–17 (2011)
54. Mankoff, J.: HCI and sustainability: a tale of two motivations. Interactions 19(3), 16–19 (2012)
55. Tufte, E.: The Visual Display of Quantitative Information, 2nd edn. Graphics Press, Cheshire (2001) ISBN 0-9613921-4-2