Sustainable Development and the Information Society

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Abstract: Sustainable development and the emerging information society are two major visions that characterize the beginning of the 21st century. This article discusses the interrelation between the emerging information society and the goal of sustainability. How can information technology contribute to sustainable development? What are the opportunities and risks of the information society with regard to the goal of sustainability?

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Key words: Information and Communication Technology, Information Society, Dematerialization, Sustainable Development, Environmental Informatics

1. INTRODUCTION

Sustainable development and the emerging information society are two major visions that characterize the beginning of the 21st century. Sustainable development is "...development that meets the needs of the present without compromising the ability of future generations to meet their own needs." (WCED, 1987).

How the emerging information society will be able to deal with the challenge of sustainable development is an open question. The rapid progress and spreading of Information and Communication Technologies (ICTs) in society creates a wide range of opportunities to approach a sustainable development path. However, technology-based strategies to attain sustainable development risk failing, if the interrelations between the

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ecological, economic and social aspects of sustainability are not taken into account.

Finding a sustainable development path is the greatest challenge for today's economy. Information technology is in principle able to do this by making it possible to reduce the use of certain production factors, especially natural resources, while increasing the use of the *production factor information*. This gain in ecological efficiency (or resource productivity) will be necessary if the earth is to feed 10 billion (10^{10}) people in a few decades from now. But how do we have to use the factor information so that we approach the goal of sustainable development?

If we take a historical perspective, we see that industrialization was a transition from a labor-intensive to a resource-intensive mode of production (see Figure 1). The factor human labor was replaced by using more natural resources, especially fossil fuels to operate machines, and with astounding success. In some areas, such as mining, labor procuctivity rose by a factor of 50.000.

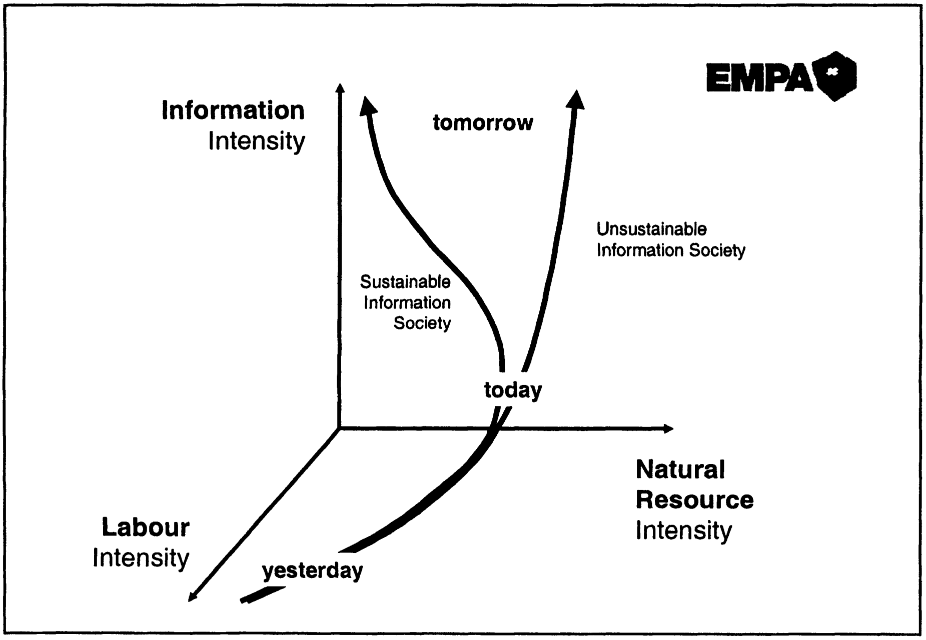

Figure 1. Paths of economic development

Today we are on the cusp of an information-intensive economy, in which nothing can be done without heavy utilization of ICTs. This is at the same time a bifurcation point in economic development: Will we succeed in reducing natural-resource intensity (left path in Figure 1) and thus in achieving a sustainable information society, or will resource consumption in the information society increase even further (right path in Figure 1)?

2. THE DEMATERIALIZATION ISSUE

Heavy increases in resource productivity are also called *dematerialization.* It is estimated that a general reduction of the material and energy flow necessary to produce one unit of added value by a factor of 4 to 10 within the next 25 years is a necessary condition for sustainable development. Dematerialization of *production* means to produce the same or a functionally equivalent product as before with much less material input. Dematerialization of *consumption* (also called "immaterialization") means to replace a material product by an immaterial service.

For several phenomena of the information society, it is sometimes taken for granted that they *are* dematerializing. However, this is a research question in each single case. Let us look at the following list: Are these phenomena examples of dematerialization?

- E-commerce replacing some shopping activities (e.g. online book retailing)
- Electronic media replacing print media (e.g. telephone directories)
- Telecommunications replacing some travel activities (e.g. video-conferencing)

The correct answer for the first two cases is: "It depends!". Many studies carried out during the last 2 or 3 years show that the impact of ICT and its use on natural resource consumption is quite complex and that the net effects can be positive or negative, depending on the system boundaries chosen and on a series of assumptions on how people use ICTs (see, e.g., the studies documented in the conference proceedings Hilty/Gilgen, 2001).

Concerning the third case, the answer is clearly "Yes". Substituting telecommunications for physical travel – even under pessimistic assumptions concerning the whole life cycle of digital electronics and the energy consumption of networks – *does* dramatically reduce the amount of natural resources necessary to perform the same function. A case study relating to an international conference the author hosted in Zurich will illustrate this point in the next section.

2.1 Case Study: How (not) to dematerialize a conference

A conference in the conventional form is a very resource-demanding process. As the host of the 15th International Environmental Informatics Symposium, the EMPA "Sustainability in the Information Society" team assessed the effectiveness of different measures in reducing the environmental impact of the conference using the Life Cycle Assessment (LCA) method. This summary focuses on carbon dioxide (CO_2) emissions as one of the most relevant aspects investigated in the study.

Based on the assumption that 500 people would participate in the conference and 1000 copies of the proceedings would be printed, we considered the following measures:

1. Reducing the printed materials produced for the conference and other materials to a minimum.
2. Eliminating the printed proceedings, and giving participants a CD instead.
3. Holding a virtual conference to which no one travels, as all speeches and discussions could be offered on the Internet.

The effects of measures (1) and (2) with regard to CO_2 reduction can be deduced from the LCA results shown in Figure 2. Eliminating the elaborate nylon book bag common at many conferences turned out to be the most effective decision. Replacing the printed proceedings with a CD ROM would have had a clearly positive effect, too. However, if the average CD user printed out any more than 20 % of the conference papers, the ecological advantage of the CD would vanish. As the organizers of the conference, we finally decided to use a simple cotton bag instead of the elaborate nylon bag, but to publish the proceedings as a conventional book.

As Figure 3 shows, when we look at the environmental impact caused by participants' travel, the discussion about the conference materials appears insignificant in comparison. Note that the scaling of the vertical axis has changed by a factor of 20. The white bar labelled "Conference Materials" includes the printed proceedings, the cotton bag as well as the materials indicated by black bars in Figure 2. In order to estimate the environmental impact of a virtual version of conference (rightmost bar in Figure 3), we assumed the double number of participants (1000), but a more selective participation by each of them (5 hours of online participation instead of 3 days of physical attendance).

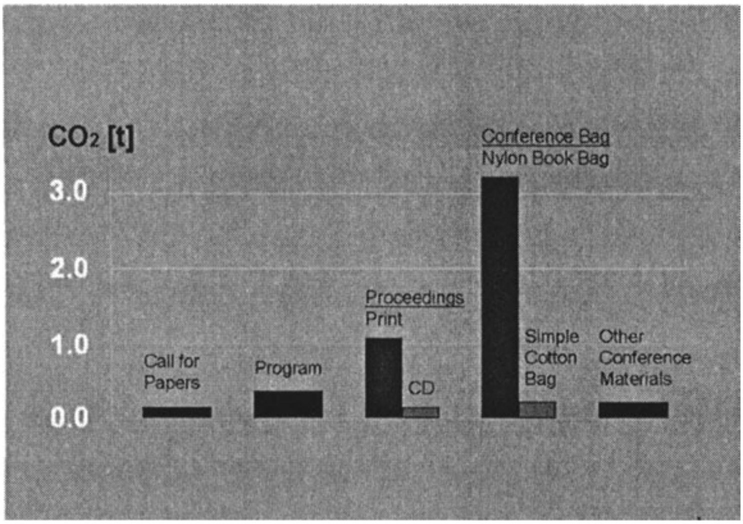

Figure 2. Carbon dioxide emissions in metric tons caused by the life cycle of different conference materials. Assumptions: Call for papers distributed in 12000 copies, 8.2 g each; program brochure distributed in 13000 copies, 30.5 g each; 1000 copies of proceedings printed, 1000 pages each; 1000 copies of CD ROM produced with simple cardboard sleeve 17.7 g; Nylon Bag: 500 pieces, 300 g each; cotton bag: 500 pieces, 100 g each; 500 copies of additional printed materials, 500 g each.

A clear result of our study is that minimizing air travel would have been the only way to achieve a significant reduction of the environmental impact of the conference. We want to emphasise that this conclusion applies even if one takes energy (in any form) instead of CO_2, or if one covers environmental impacts using full aggregation into ecopoints (using the ecological scarcity method) or eco-indicator points (using the Eco-indicator 99 method). For a broader discussion of the results see Hischier and Hilty (2002). All life cycle data for print media and the Internet used in this study were based on an earlier EMPA study that investigated the environmental impacts of print and electronic media (Reichart and Hischier 2001).

A concept which might deserve consideration in the future is that of a decentralized conference which takes place at several locations that can be reached with practically no air flights, which are connected to one another live by suitable telecommunication facilities. Then the experience of direct contact to a smaller group would be available, and a global dialog would still be possible.

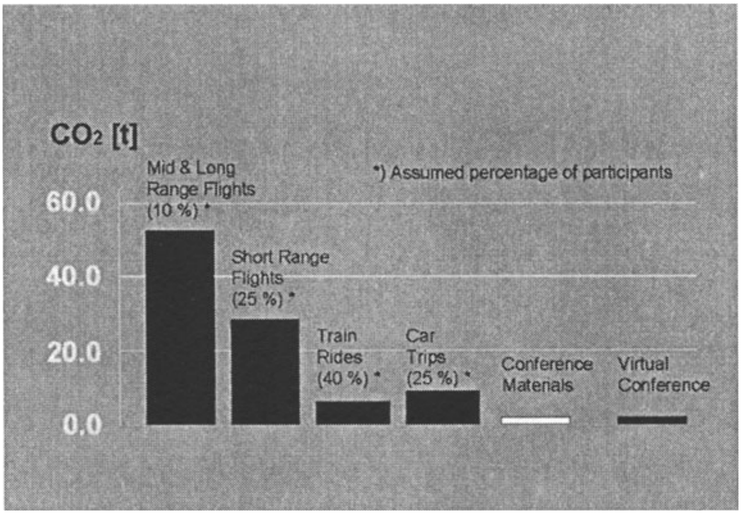

Figure 3. Carbon dioxide emissions in metric tons caused by the travel of conference participants, by the conference materials including the printed proceedings, and by a virtual conference. Assumptions concerning the virtual conference: 1000 participants that are connected to the Internet for 5 h, transferring data during 3 h at 64 kBit/s and printing out 100 pages each.

3. A CLASSIFICATION OF THE IMPACTS OF ICT ON SUSTAINABLE DEVELOPMENT

An evidently positive impact of ICT on sustainable development we have not mentioned so far is the application of ICT to environmental problems (see Table 1, upper part). The discipline of applying information and communication techniques and technologies to environmental research, planning and protection is called *Environmental Informatics* and has emerged in the 80ies. See Hilty/Ruddy (2000) and Rautenstrauch (2001) for more detail on environmental informatics.

However, *general* applications of ICTs such as Internet-based services seem to account for most of the sustainability impact of these technologies (see Table 1, lower part).

Still assuming that increasing the resource productivity of the economy is a necessary condition for sustainable development, we have to face the fact that the direct contribution of the ICT hardware life cycle (production, use, disposal) to the overall material and energy throughput of the economy is no longer negligible. The production of millions and billions of PCs or mobile phone sets for a relatively short use phase is a relevant sink of natural resources. IBM estimates that only 1.4 % of the total physical mass processed in PC production becomes part of the final product. After a short use phase of 3 years on the average, even these 1.4 % cause enough trouble as electronics waste. Estimates of the energy needed for the production of one PC vary between 6 and 12 GJ of primary energy, more than the energy consumption during the total use phase of the device (as long as it is not used as a server and never switched off). These examples illustrate that the direct negative impact of ICTs on resource productivity might be relevant (for more detail see Hilty et al., 2000).

However, the *indirect* impacts of ICTs on sustainable development will predominate, because they affect the production and consumption patterns of the whole economy. As shown in Table 1, the indirect impacts can be classified under the following three types. The scheme was originally introduced to classify the impacts of telecommunications on physical traffic and can be explained best using this special case as an example. Note, however, that we are generalizing this scheme to cover all kinds of ICT and their respective impacts on all kinds of physical processes.

Environmental Applications of ICTs (Environmental Informatics)	**Public sector:** Environmental Information Systems (EIS) operated by public authorities	Public awareness about condition of public goods
		Prerequisites for political decisions
		Executing instruments of environmental policy
	Private sector: Environmental Management Information Systems (EMIS)	Legal compliance, compliance to standards
		Environmental reporting to stakeholders
		Eco-efficiency and material flow management
General Applications of ICTs	**Direct impact** on the material intensity of the economy	Life cycle of ICT hardware: production, use, disposal of electronic devices
	Indirect impact on the material intensity of the economy	Substitution potential
		Optimization potential
		Induction potential

Table 1. Types of impacts of ICT on sustainable development

- Substitution: Telecommunications is substituted for physical traffic
- Optimization: Telecommunications helps to optimize traffic systems.
- Induction: Telecommunications induces traffic (e.g. by enabling distributed forms of production).

Let us demonstrate how this scheme applies to other domains as well, using paper consumption as an example.

3.1 Example: Paper consumption [22]

The PC as the modern form of typewriter and especially the PC as a medium to access e-mail, WWW and other Internet services does have some potential to reduce paper consumption. Plenty of textual and graphical information can be received directly from the screen, which in fact is *substituted* for paper in many cases. There is also an *optimization* effect, since for instance many errors can now be corrected before a text or picture is printed for the first time. However, as the reader may know from everyday experience, the *induction* effect offsets the other effects by far, because today's PC and printer technology enables the user to print out hundreds of pages with just a few mouse clicks. Therefore, all in all, ICTs contribute to the same general trend for paper that has been observed for the past 60 years (Ehrenfeld, 1997). Moreover, per-capita paper consumption is now seriously considered an *indicator of affluence*. Newspapers recently celebrated the fact that an average Swiss person now consumes 240 kg of paper per year.

4. THE REBOUND EFFECT

The counter-intuitive trend that can be observed in paper consumption is just one example of a phenomenon known as the *rebound effect*. This concept refers to a potential created by efficiency gains that is balanced off or even overcompensated for by quantitative growth (Binswanger, 2001).

Originally the rebound effect was discovered in the energy sector. Energy productivity (the quotient from gross domestic product and total energy consumption) has been growing for a few decades now in highly developed countries by about 1 % per annum. This "savings", though, is overcompensated by growth in the gross domestic product (about 3 % per annum), so that in absolute figures more energy is consumed every year.

[22]The inconsistent numbering of this subtitle is acknowledged to Bill Gates and his Microsoft Office ™ products.

The situation will be hardly different in the information society: Every substitution or optimization effect achieved by ICT creates new degrees of freedom which tend be used for quantitative growth. Very often, it is the old technologies that continue to grow, while the new ones are used additionally, helping to extend the limits which the old technologies would have eventually hit.

The most striking example of the rebound effect is ICT itself. According to Moore's law, digital electronics dematerializes in fact by a factor of 4 every 3 years. That raises the question as to why this continuing dramatic dematerialization has not caused a corresponding reduction of the total energy and material flows caused by ICTs. On the contrary, though, electronics' share of energy consumption continues to increase, and the amount of electronics waste indicates that material throughput is growing just as fast. This apparent contradiction is a typical example of the rebound effect: the rapid dematerialization has been compensated for – even definitely overcompensated for – by growth in the demand for computing and technical communication power for several years now.

As far as ICTs lead to time savings, a rebound effect always comes up given constant time budgets, when the replacement activities are comparable or even more demanding as regards material or energy needs. This also seems to be the reason that an increase in telecommunications has not led to a net reduction in traffic thus far, which is empirically true according to most of the studies in this field.

The rebound effect is the most serious risk on the way to a sustainable information society, because it compensates for the increase in resource productivity made possible by ICTs.

5. THE DIGITAL DIVIDE

Another obstacle on the way to a sustainable information society is a social problem known as the *Digital Divide.* Of the many social risks brought about by ICTs, the digital divide is the one most seriously conflicting with the goal of sustainability. This divide can be found within the rich societies of the Global North, but it is especially severe between the Global North and the Global South (global digital divide).

The Internet is a driver of economic globalization and tends to deepen the split between the winners and the losers of globalization. If the opportunities that the Internet surely offers for developing countries are to be used, special measures must be taken to ensure universal access to ICTs. Whereas international development cooperation has been focussed on agriculture to overcome the global farming divide in the past, and today focusses on environmental technology, tomorrow attention will have to be paid to bridging the digital divide.

The question as to which of digital divide projects will be successful seems to depend on the three factors shown below. As initial experiences have shown, the optimal combination of these factors is most likely to be stuck upon by partnerships that provide the various competencies needed for success. Such partnerships can consist of international development agencies, intergovernmental bodies such as the United Nations, local NGOs or host governments:

1. Not only technical infrastructure is needed, but also appropriate regulatory frameworks that ensure low-cost access for broad social groups.
2. There should be measures to provide training in ICT, to keep graduates in the host country and to replace foreign experts.
3. Promote nationally or regionally specific Web services and local content in languages other than English. Then multipliers can effect interchange with indigenous populations. These regional services should be combined on the Internet in keeping with a national "e-strategy" that includes "e-government".

6. CONCLUSION

The transition to a global information society holds many opportunities for sustainable development. Environmental informatics leads to a better understanding of the complex natural environment on which our lives depend. The information society also offers great potential to dematerialize products and services, which means to increase natural resource productivity dramatically.

However, technical progress in the direction of dematerialization is only a necessary, but not a sufficient condition for approaching the goal of sustainability. There is a high risk that efficiency gains will be compensated for by rebound effects, as can be learned from history as well as from economic models. Therefore, politics should create framework conditions which lead to an optimal allocation of scarce ecological resources through market mechanisms.

Besides the rebound effect, a serious obstacle on the way to a sustainable information society is the growing global digital divide.

How society can counteract these risks on its way to an information society is clearly a political and cultural issue.

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