The Role of ICT to Achieve the UN Sustainable Development Goals (SDG)

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Abstract. This paper is aiming at illustrating the potential of ICT for achieving the Sustainable Development Goals which were declared by the United Nations in 2015 as binding for all nations of our planet addressing both developing and developed countries. ICT must play a significant role if the SDGs should be achieved as projected in 2030. The paper gives an overview of some of the existing efforts in this area and is written as an appeal to all professionals, scientists and IT-professional and their organization to take a holistic approach for all ICT-activities and projects to always include and monitor the effects of their work on the SDGs. The impacts of ICT on sustainability are twofold: On the one hand there might be negative effects on sustainability such as the generation of electronic waste, on the other hand ICT is definitely an enabler to more efficient resource usage, education and business operations which is critical success factor for achieving the SDGs.

Keywords: Sustainable development goals · Millennium development goals · WSIS · Code of ethics · Impact of IT-work on sustainability · Karlskrona manifesto

1 Introduction

On 25th to 27th of September 2015, the heads of state and high-representatives of United Nation's member nations agreed on the Sustainable Development Goals (SDGs) which supersede the Millennium Development Goals. The Millennium Development Goals (2000–2015) can be regarded as one of the most important and successful initiatives to eradicate poverty in modern history. The eight crystallized goals of the MDGs have been further translated into practical steps which have deliberated over one billion people from an extreme level of poverty and have achieved a better standard of life in many parts of the world. [19] Without any doubt one cannot neglect the eminent role of science, technology

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and innovation as well as the dissemination of these new technologies in most of the practical steps leading to a society where no one should be left behind.

The aim of the SDGs is to set the objectives for driving forces all over the world to tackle the world's largest challenges such as fighting poverty, eliminating inequalities and achieving sustainable economic growth. The agenda comprises 17 SDGs which are further refined to 169 targets addressing economic, social and environmental aspects [20].

A key aspect of the agenda is that the defined goals address all countries. All countries of our planet are obliged to perform their level best to consider and enforce all their efforts to achieve within one generation a significant reduction of inequalities in their societies. This should be achieved in least developed countries, developing countries, middle income countries but also in the developed countries. Furthermore, this development should take into account a balancing of the economic, social and environmental factors towards a safe and sustainable planet [20].

No other domain in the recent past had such a strong influence on the development of countries and societies than information and communication technologies (ICTs), especially in driving today's innovation, efficiency and effectiveness across all sectors. ICT has been the fastest growing sector since a generation. The World Summit on Information Societies (WSIS) in 2003 and 2005 was devoted to the potential of ICTs towards the vision of "a people centered, inclusive and development-oriented information society" where everyone can have the potential to access and share information available (on the Web). Bridging the digital divide is essential for all people left behind to utilize potentially available information to create new businesses and (local) knowledge. We should be aware of the importance of local content in the local languages for taking advantage of information on the Web. The fundamental aim of the WSIS process was the improvement of peoples' life through a better use of ICTs.

The eleven action lines of WSIS are highly relevant for all the necessary efforts to achieve the SDGs.

This paper is aiming at sketching the enormous potential of ICT to accomplish the SDGs which cover the three dimensions of economic prosperity, social equity and environmental sustainability in 2030.

It is necessary for an organization like IFIP to make it explicit to all people working in the field of information processing to align their work to the SDGs which are global in the sense that they are binding for both the developed and the developing countries.

2 Role Models Within Computer Societies on Direct or Indirect Initiatives Toward SDGs

The International Federation for Information Processing (IFIP) [9] is an umbrella organization for information technology societies in more than 56 countries all over the world. The role of information technology on society has been discussed in different working groups of the Technical Committee 9 "ICT and Society" since 1976.

Already in 2005, an IFIP Working Group for "ICT and Sustainable Development" [10] was established to provide the platform for discussion and research on this eminent important topic for building a global society where nobody should be left behind which is also sustainable for future generations.

This IFIP Working Group covers the necessary promotion of research on the interactions amongst the social, environmental and economic impacts of ICT towards a sustainable society for generations to come. This includes the coordination of policy issues concerning synergies of a multi-stakeholder and people-centered driven information society and sustainable development targets.

The scope of this working group also covers the important aspect of early warning on (possible negative) impacts of ICT- applications and innovation to enable a strategic forecast of coming new technologies in the area.

In their Code of ethics ACM defines 24 imperatives which set ACM's expectations of a member. Many of the mentioned principles such as "Contribute to society and human well-being", "Be honest and trustworthy" or "Know and respect existing laws pertaining to professional work" reflect ethical behavior which in a very general manner build prerequisites for ICT to be a facilitator in reaching the SDGs.

In line with these principles, the Code of ethics of the ACM/IEEE-CS Joint Task Force on Software Engineering Ethics and Professional Practices defined the following eight principles for software engineers [1]:

1. *"PUBLIC - Software engineers shall act consistently with the public interest.*
2. *CLIENT AND EMPLOYER - Software engineers shall act in a manner that is in the best interests of their client and employer consistent with the public interest.*
3. *PRODUCT - Software engineers shall ensure that their products and related modifications meet the highest professional standards possible.*
4. *JUDGMENT - Software engineers shall maintain integrity and independence in their professional judgment.*
5. *MANAGEMENT - Software engineering managers and leaders shall subscribe to and promote an ethical approach to the management of software development and maintenance.*
6. *PROFESSION - Software engineers shall advance the integrity and reputation of the profession consistent with the public interest.*
7. *COLLEAGUES - Software engineers shall be fair to and supportive of their colleagues.*
8. *SELF - Software engineers shall participate in lifelong learning regarding the practice of their profession and shall promote an ethical approach to the practice of the profession".*

All eight principles can be assigned to the sustainable development goals. As a "pars pro toto" -example we will illustrate the relevance of these code of ethics principles for software engineering professionalism by means of a (hypothetical) "Volkswagen-like" case on the basis of the eight principles described above (i.e. a case where software has been built to deliver manipulated environmental data to fulfill existing binding environmental standards). Since all the details of the

Volkswagen-case are not yet clarified and disclosed we do not refer to the "real" Volkswagen-case. However, we want to show that compliance to the ethical principles may even prevent enormous damages in "Volkswagen-like"-cases.

For the first principle ("Public") ICT-workers should very much internalized the idea that the usage of their products must be compliant with the environmental, economic and social requirements of its deployment. In our case it could be imagined that already in the requirement analysis phase one could have detected a conflict of interest between the goals of the software to be built which could lead to manipulated results and the public interest of clean air which are defined by the binding environmental standards (both national and internationally for the target countries where the cars are sold).

Principle 2 ("Client and Employer") is also breached due to the negative effects on car-buyers and ultimately also for the employer. For a car maker the penalties of such breaches can go into billions of US-dollars and it would be the task of every ICT-worker to warn the employer about the consequences of the misuse of software. Introducing a mandatory independent monitoring and/or auditing of SDGs for large projects with possible very damaging impacts could be an approach which should be considered in the future. This could also be important for all kinds of breaches which would cause reputational damage (e.g. child-labor).

The principle of "Judgement" is a prerequisite for an overall ethical-driven work of ICT-workers in their (team) work. For educational institutions and universities, the inclusion of SDGs into the curricula will be an important target of the near future. ICT-managers should handle SDG-requirements with equal importance to all other quality criteria within their software development process. The reputation of ICT-workers can be very much advanced by the potential of software to reduce negative impacts on sustainability. Lifelong learning is prime for keeping track with newest developments where ICT will function as one of the most important enabler for achieving the SDGs in 2030.

Recently through the initiative of a few prominent software engineering scientists in the area of requirement engineering the so-called Karlskrona Manifesto for Sustainable Design is formulated where inter-alia the following disposition of existing awareness within the software engineering community is stated [3].

The coherent and proper analysis of the initiators of the Karlskrona manifesto on the existing increasing consciousness within the software engineering community lead to the proposal of an initial set of principles and commitments [2]:

"Sustainability is systemic.
Sustainability has multiple dimensions.
Sustainability is a concern independent of the purpose of the system.
Sustainability applies to both a system and its wider contexts.
Sustainability requires action on multiple levels.
System visibility is a necessary precondition and enabler for sustainability design.
Sustainability requires long-term thinking. (i.e. We should assess benefits and impacts on multiple timescales, and include longer-term indicators in assessment and decisions.)

It is possible to meet the needs of future generations without sacrificing the prosperity of the current generation. (i.e. Innovation in sustainability can play out as decoupling present and future needs. By moving away from the language of conflict and the trade-off mindset, we can identify and enact choices that benefit both present and future." [2]

A forerunner of the initiatives towards the role of ICT to combat global warning was the ICT-GLOW-initiative in 2010/2011 which leads to the establishment of the International Conference on ICT as Key Technology for the Fight against Global Warming in Toulouse, France in 2011. [11] A special track on "Cloud Computing for the Public Sector" completes this gathering of experts in the field. Already here the two aspects of the involvement of ICT for sustainability has been pointed out, i.e. on the one hand issues on the potential of ICT as enabler for the reduction of CO2-emissions and on the other hand, issues on the urgent need of systems which are designed and operated in an energy-aware way leading to a minimization of energy consumption [11].

"Sustainability design as introduced by Becker et al. in the context of software systems is the process of designing systems with sustainability as a primary concern, based on a commitment to these principles." [2]

The above mentioned initiative in the field of requirement engineering clearly shows the holistic character of sustainability. However, one can state that this initiative is skewed to the environmental dimension of the SDGs which is still the main focus in the Northern hemisphere. The economic dimension of SDG for achieving economic prosperity and social equity is not in the center of the manifesto.

An approach which does not single out the aspect of eradication of the global imbalance was sketched in [17] where the challenges of this decade with respect to necessary adaptation of the ICT-work of scientists and professionals concerning social, economic and ethical challenges are briefly summarized.

Especially aspects of the elimination of economic poverty due to the use of mobile devices in the area of e-commerce and aspects of the use of crowd-sourcing for e-health applications were discussed.

In 2013, a very successful conference-series ICT for Sustainability (ICT4S) was started in Zurich with the support of the universities in Zurich with a predominant focus on environmental sustainability [8].

It can be stated that a lot of efforts are still needed for the holistic investigation of the use of ICT to achieve the SDGs. Therefore, in the next section we point out sectors of ICT which could significantly contribute to the success of SDG by 2030.

3 Possible Contribution of ICT to the SDGs

Hilti and Aebischer [7] categorize the effect of ICT as follows: Level 1 ("direct effects") describe the negative effects of ICT which comprises the production and disposal. Level 2 ("enabling effects") are those effects which arise from the application of ICT. Unlike to level 1, these effects can be either positive

(e.g. substitution effect, optimization effect) or negative (e.g. induction effect, obsolescence effect). Level 3 ("systemic effects") refer to long-term impacts of ICT services on socio-economic systems. These impacts can also be positive (e.g. sustainable patterns of production and consumption) or negative (e.g. new emerging risks).

Further, the authors [7] outline how different domains in computer science, such as Environmental Informatics or Computational Sustainability, contribute to the achievement of sustainable ICT.

According to an Ericsson report [4] can accelerate the achievement of the SDG in five ways: (1) ICT spreads in a very fast way which can be best demonstrated by the uptake of mobile technologies reaching seven billion subscribers in 2015. (2) ICT can help to save costs in various sectors such as health, banking, or education. (3) ICT can help to point out the awareness of new technologies. Unlike in the past, information about new technologies can spread at enormous speed using social networks, mobile technologies or other electronic channels. (4) National and global information flows are enhancing and upgrading new applications. (5) Through the usage of ICT low cost online platforms can be established to educate workers in new technologies [4].

In its mapping, WSIS mapped its action lines to the sustainable development goals. For each mapping in the table a detailed rationale is given in the report. In the following we briefly outline the action lines as described by WSIS. [24] The action line C1 ("Role of Government and all Stakeholders in the Promotion of ICT for Development") [23] highlights the importance of the buy-in from governments and stakeholders in order to establish the Information Society. C2 ("Information and communication infrastructure: an essential foundation for the Information Society") [23] demands adequate infrastructure enabling affordable and ubiquitous access to ICT. C3 ("Access to information and knowledge") [23] outlines that individuals and organizations should take advantage from access to information and knowledge using ICT. C4 ("Capacity building") [23] states that every person should have the knowledge and skill set to profit from the Information Society. Further, actions how ICT can support education and lifelong learning activities are outlined. C5 ("Building confidence and security in the use of ICTs") [23] highlights the central value of privacy, trust and security for the Information Society. C6 ("Enabling environment") [23] points out actions to increase the confidence in the Information Society. C7 ("ICT applications: benefits in all aspects of life") [23] highlight that ICT can improve the sustainable development in various areas such as e-government, e-business, e-learning, e-health, e-environment, e-agriculture, and e-science. Within the WSIS-SDG matrix C7 is refined into the individual applications. C8 ("Cultural diversity and identity, linguistic diversity and local content") [23] stresses that cultural and linguistic diversity poses a critical success factor in the development of an Information Society. C9 ("Media") [23] outlines the importance of media in all its forms in the development of an Information Society. C10 ("Ethical dimensions of the Information Society") [23] emphasizes the relevance of ethics within the Information Society to avoid abusive usage of ICT. C11 ("International and regional cooperation") [23] points out that international cooperation is indispensable in order to eliminate the digital divide.

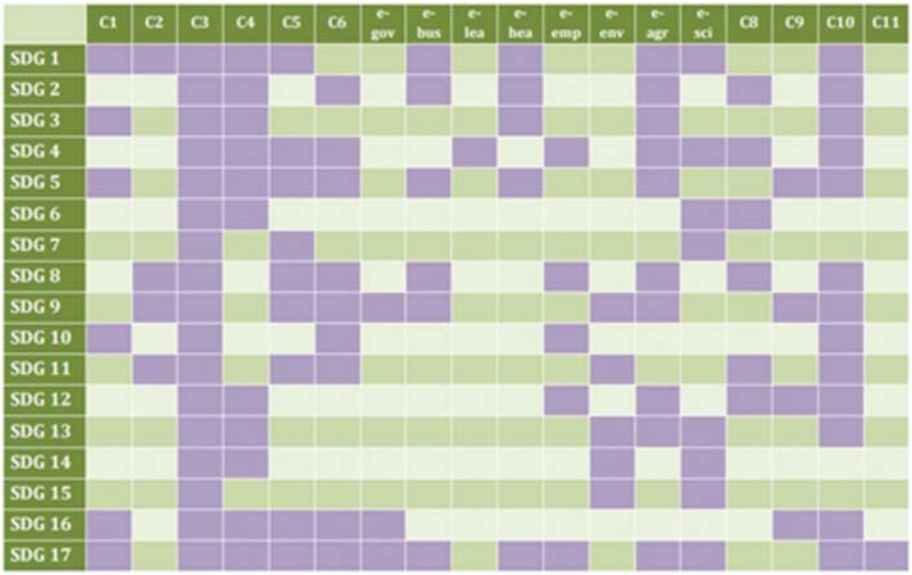

Fig. 1. WSIS action lines - SDGs matrix [24]

In the following we highlight possible opportunities for a subset of the SDG. Due to space limitations we decided to tackle a few goals in more detail instead of providing an abstract view on every SDG (Fig. 1).

SDG 4: Ensure Inclusive and Equitable Quality Education and Promote Lifelong Learning Opportunities for All. ICT plays a major role in order to achieve quality education and lifelong learning possibilities as expressed within SDG 4. Platforms, such as Massive Open Online Courses (e.g. Coursera, Udacity, edX, iVersity, Khan Academy) which are available for free through the Internet highlight how (even specialized) knowledge can be made available to a wide public. Furthermore, online social networks and Web 2.0 platforms (such as YouTube) are widely used to spread knowledge via the internet in order to facilitate lifelong learning.

Another success story in providing information and education to everybody is the online encyclopedia Wikipedia which is a free-of-cost encyclopedia developed by using the knowledge of the community [21].

Open Access publications, such as Springer Open, are gaining popularity and support the accessibility of scientific contributions. Further, research social networks, such as Research Gate, establish the exchange between researchers and scholars all over the world. Open Source products (e.g. Linux, LibreOffice, Eclipse) and initiatives pose alternatives to expensive software suites and minimize thereby inequalities in education.

In order to design content on the internet in an inclusive way, the W3C started his Web Accessibility Initiative [25].

Initiatives setting common standards in education of digital competencies, such as the European e-Competency Framework (e-CF) [5] and the ICT profiles project [6] building upon, highlight which ICT competencies should be taught in order to address today's challenges. Although released 2014, the competency framework already addresses sustainable development.

SDG 11: Make Cities and Human Settlements Inclusive, Safe, Resilient and Sustainable. So called smart cities envision more effective usage of resource in urban areas supported by ICT. (Research) initiatives in the domain "intelligence transport system" will contribute to improvements in traffic planning. Self-driving vehicles which are currently one of the hottest innovations in car industry highlight how ICT could be an opportunity for aging society to keep mobile.

Smart metering systems and smart distribution systems can support the sustainable usage of electric power. Analogue to the usage of electric power smart distribution and management systems are currently under research to facilitate the efficient usage of water. ICT platforms enable participatory urban planning projects where citizen can express their opinions. eGovernment systems open up the possibility to complete administrative processes from anywhere.

Furthermore, ICT is key technology in assisting decision makers and responders during disasters. Thus, in the future ICT systems have to be created supporting the objectives of the Sendai framework. [18]

3.1 Joint Proposal of ICT Indicators for the Sustainable Development Goals Indicator Framework

This proposal has been prepared for the expert group meeting on an indicator-framework for the post-2015 development. It contains ICT indicators (e.g. individuals using internet or E-waste collection rate) and available datasets (e.g. datasets collected by ITU or UNU) which are required to calculate the impact on sustainability [15].

It should not be unmentioned that non-profit organizations have taken many initiatives in the efforts to instrument ICT as an enabler to achieve the SDGs. A prominent example is the SDG ICT Playbook of NETHOPE, representing more than 40 international non-profit organizations, which provides guidance on how ICT can support the achievement of the SDG. Therefore, SDG are linked to sector demands that could profit from the application of information technologies. These ICT solutions are further mapped to key underlying technologies, challenges and recommended methods addressing the challenges [14].

3.2 Towards a Compliant ICT-working Effort for SDGs

It is evident that the use of ICT has also facets which endanger the environment of our planet, e.g. the problem of electronic waste, cheap labor in the production process of IT-equipment etc.

More importantly however, as it has been pointed out above, ICT will play a most important role to achieve the SDGs. The ICT-scientific-community has

to be aware that this role of ICT as an enabler is a very noble one. Especially in the "pure" academic world unfortunately still there exists the tradition to depreciate the role of a discipline as an auxiliary science.

In the opinion of the authors it is high-time to (a) consider the impact of all our work as ICT-scientists and professionals with respect to its three dimensions of SDG in achieving economic prosperity for all, social equity and environmental sustainability.

IFIP has committed in its Milan Declaration in 2008 that the ICT profession should be founded on the essential elements of professionalism Competences (including knowledge), Integrity, Responsibility and Accountability and Public Obligation. In 2016 it should be mandatory that the notion of responsibility should be coined to all aspects of the SDG [13].

In the following we want to exemplarily point out just a few areas within the ICT-landscape where scientists and other professionals could contribute to the fulfillment of the SDGs or at least plays a role in mitigating economic, social and environmental disasters.

A few examples should illustrate the above role of ICT:

- In the field of Software Engineering it will be essential that both the compliance with Code of Ethics and severe sustainable monitoring of large software projects are considered as instruments to prevent environmental damaging software as described above in Volkswagen-like-cases. Taking the Karlskrona Manifesto as a compliance-guideline for Software Engineers would have prevented such a disaster.
- In the area of Sustainable Supply Chain Management one could use advance text mining and Bayesian Networks techniques to detect child labor in the supply chain. [16]
- Methods of crowd-sourcing could be used to early detect epidemics and agricultural plagues using big-data techniques.
- In education the MOOC-approach of disseminating knowledge for higher education also to the third world is an example for a successful impact of ICT. Here we can mention the LEJ Knowledge Hub of Pakistan as a role model where thousands of Courses are delivered by world authorities in Science, Engineering, Agriculture, Social Sciences, Economics and other fields are freely available at school, college and university levels. [12]
- In the area of Disaster Risk Reduction, ICT has achieved very successful which are originated in developing countries. Ushahidi's success in many catastrophes as the earthquake in Haiti shows us that open source software can play a key role. [22]

It should be mentioned that IFIP has just established an "IFIP Domain Committee on IT in Disaster Risk Reduction" where an interdisciplinary bundling of IT-knowhow and other disciplines should enable significant disaster risk reduction.

4 Conclusion and Future Work

In this paper we emphasize the important role of ICT to achieve the Sustainable Development Goals, the so called SDGs (2016–2030) which follow the Millenium Development Goals- MDGs (2000–2015). In contrast to the MDGs the SDGs are binding for all countries developed and developing- and cover holistically the economic, social and environment dimension.

We are convinced that the conformance to the Code of Ethics which significantly include "sustainability" should be self-evident for every IT professional as in other disciplines the Hippocratic Oath is binding for medical doctors.

However, it will be an important requirement of the next future that for all ICT-projects and enterprises sustainability is included as a new dimension which is monitored by all internal audit functions of the involved organizational entities. For this reason, we are convinced that auditable standards and best practices on internal sustainability controls as well as performance indicators are required to ensure the conformance with these new objectives.

References

1. ACM/IEEE-CS: Software engineering code of ethics and professional practice (2016). http://www.acm.org/about/se-code. Accessed June 2016
2. Becker, C., Betz, S., Chitchyan, R., Duboc, L., Easterbrook, S.M., Penzenstadler, B., Seyff, N., Venters, C.C.: Requirements: the key to sustainability. IEEE Softw. **33**(1), 56–65 (2016)
3. Becker, C., Chitchyan, R., Duboc, L., Easterbrook, S., Mahaux, M., Penzenstadler, B., Rodriguez-Navas, G., Salinesi, C., Seyff, N., Venters, C.C., Calero, C., Kocak, S.A., Betz, S.: The karlskrona manifesto for sustainability design (2015). http://sustainabilitydesign.org/karlskrona-manifesto/. Accessed June 2016
4. Ericsson, The Earth Institute, Colombia University: ICT & SDG - How Information and Communications Technologies ccan Achieve the Sustainable Development Goals. Report (2015). https://www.ericsson.com/res/docs/2015/ict-and-sdg-interim-report.pdf
5. European Committee for Standardization (CEN): European e-competence framework 3.0 (2014). http://ecompetences.eu/wp-content/uploads/2014/02/European-e-Competence-Framework-3.0_CEN_CWA_16234-1_2014.pdf
6. European Committee for Standardization (CEN): ICT Profiles (2016). http://www.ecompetences.eu/ict-professional-profiles/
7. Hilty, L.M., Aebischer, B.: ICT for sustainability: an emerging research field. In: Hilty, L.M., Aebischer, B. (eds.) ICT Innovations for Sustainability. Advances in Intelligent Systems and Computing, vol. 310, pp. 3–36. Springer, Heidelberg (2015)
8. ICT4S: ICT4S 2013 - ICT for Sustainability - The Challenge of Making It Real (2013). http://2013.ict4s.org/
9. International Federation for Information Processing (IFIP): About IFIP (2016). http://www.ifip.org/index.php?option=com_content&task=view&id=124&Itemid=439. Accessed June 2016
10. International Federation for Information Processing (IFIP): TC 9- ICT and Society - Aims and Scopes (2016). http://www.ifip.org/bulletin/bulltcs/tc9_aim.htm. Accessed June 2016

11. Kranzlmüller, D., Toja, A.M. (eds.): ICT-GLOW 2011. LNCS, vol. 6868. Springer, Heidelberg (2011)
12. LEJ KnowledgenHub (2015). http://lej4learning.com.pk/
13. Milan Declaration: WCC 2008 Declaration on ICT Professionalism and Competences (2008). http://ipthree.org/milan-declaration/
14. NETHOPE: SDG ICT Playbook - From Innovation to Impact (2015)
15. Partnership on Measuring ICT for Development: Background note: Joint proposal of ICT indicators for the Sustainable (2015)
16. Thoeni, A.: Sustainability Risk Monitoring in Supply Chains Ranking Suppliers using Text Mining and Bayesian Networks with a Focus on Child Labor. Ph.D. thesis, Vienna University of Technology (2015)
17. Tjoa, A.M.: Next decade of social, economical and ethical challenges - perspectives of a networked world. In: 24th IEEE International Conference on Advanced Information Networking and Applications. IEEE Computer Society (2010)
18. UNISDR - The United Nations Office For Disaster Risk Reduction: ICTs and the Sendai Framework (2016). https://www.unisdr.org/archive/47522. Accessed June 2016
19. United Nations: The Millenium Development Goals Report, New York (2015)
20. United Nations: Transforming Our World: The 2030 Agenda For Sustainable Development, New York (2015)
21. Wikipedia: From wikipedia, the free encyclopedia, (06 2016). https://en.wikipedia.org/wiki/Wikipedia. Accessed June 2016
22. Wikipedia: Wikipedia - ushahidi (2016). https://en.wikipedia.org/wiki/Ushahidi
23. World Summit on the Information Society (WSIS): Plan of action, December 2003. Accessed June 2016
24. World Summit on the Information Society (WSIS): WSIS - SDG Matrix (2016). Accessed June 2016
25. World Wide Web Consortium (W3C): Designing for inclusion (2016). https://www.w3.org/WAI/users/Overview.html. Accessed June 2016