

GreenICTComp



ICT ja ilmasto, 3/4



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GreenICTComp

ICT-alan kädenjälkivaikutukset



ICT ja ilmasto

JALANJÄLKI

ICT-alan tärkeimmät ilmastonmuutosta kiihdyttävät seikat ja niiden ymmärtäminen osana tietoyhteiskuntakehitystä. Mikä on ilmastonmuutos? Mitä on ICT? Mikä on jalanjälki?

JALANJÄLKIVAIKUTUSTEN LINKITTYMINEN

ICT-alan jalanjälkivaikutusten aikaskaala, linkittyminen muihin yhteiskunnan toimintoihin sekä vastuu vaikutuksista.

KÄDENJÄLKI JA MUUT KESTÄVYYDEN DIMENSIOT

ICT-alan kädenjälkivaikutukset eri aloilla, kuten liikkuminen, logistiikka, maatalous, teollisuus ja älyteknologiat. ICT-alan merkitys ilmasto- ja ympäristötyössä. Edellisten pohjalta alan suurimmat tunnistetut haasteet ja niiden rajaaminen kestävyysongelmiksi.

SUSTAINABILITY MINDSET JA YHTEENVETO

Edellisiin kertoihin pohjaten mitä voisi tehdä toisin? Yhteenveto ja koulutuksen aikana tehtyjen tehtävien esittely.



Tavoiteltavat oppimistulokset

- Tämän luentokerran jälkeen opiskelija:
 - tuntee ICT:n merkityksen muiden alojen muuttajana
 - ymmärtää eri alojen päästövaikutuksia
 - ymmärtää, että ICT:n avulla muiden alojen jalanjälkeä voidaan pienentää
 - ymmärtää vähennyspotentiaalin eri aloilla



Luennon agenda

- Kotitehtävän purku
- Digitalisaatio ICT:n käytön pohjana
- ICT:n käyttö eri aloilla
- ICT-alan merkitys ilmasto- ja ympäristötyössä kädenjäljen kautta
- Ympäristövaikutusten linkitys muihin kestävyysdimensioihin (luontojalanjälki)
- Kotitehtävä



Tehtävä

Vastaa jälleen aloitustehtävän kysymyksiin.

Aikaa käytettävissä noin 5 minuuttia.

<https://forms.gle/va2uZAJ2UXS7mGJx6>



Kotitehtävän purku



Edellisen kerran tehtävä

Jatka työskentelyä valitsemasi ICT-palvelun parissa. Etsi materiaalia oman aihepiirisi päästöistä – **mistä ja missä ne muodostuvat ja pohdi kuka niistä on vastuussa?** Tiedon päästöistä ei välttämättä tarvitse olla tarkka numeerinen arvo, suurusluokka ja/tai tieto päästölähteistä riittää.

Pohdi myös **mitä muita ympäristövaikutuksia kuin CO₂-päästöjä voitaisiin mitata.** Palauta tehtäväsi ennen seuraavaa kertaa.

Varaudu jälleen esittelemään vastauksesi seuraavalla kerralla hyvin lyhyesti.



Digitalisaatio



Digitalisaation määritelmä

- Digitalisaatio on prosessi, jossa **jokin muunnetaan digitaaliseen muotoon (digitization vs. digitalization)**
 - Viittaa tiedon digitalisointitekniikkaan. Digitalisoitu tieto koostuu yleensä binäärinumeroista, joita voidaan käsitellä tietokoneilla. Tietokone purkaa numerot ja tuottaa tietoa, joka on ihmisen luettavissa.
 - Painotuotteiden siirto digitaaliseen mediaan.
- Digitaalisten teknologioiden **integrointi jokapäiväiseen elämään** digitalisoimalla kaikki, mikä voidaan digitoida.
 - Digitalisaatiolla tarkoitetaan myös prosessia, jossa kaikki digitoitavissa oleva tehdään digitaaliseksi ja informaatio muunnetaan digitaaliseen muotoon.
 - Tieto- ja viestintätekniikan mahdollistama muutokset (change and transformation) maailmassa.



Digitalisaation määritelmä

- Digitalisaatio on **digitaalisten teknologioiden** käyttöä uusien tulojen ja arvon tuottamiseen liittyvien mahdollisuuksien tarjoamiseen, digitaaliseen liiketoimintaan. - Gartner
 - Digitaalisten teknologioiden käyttöönotto liiketoimintamallin muuttamiseksi. Tavoitteena on luoda arvoa uusien, kehittyneiden teknologioiden käytöstä hyödyntämällä digitaalista verkkodynamiikkaa ja digitaalista tiedonsiirtoa.
 - Digitalisaatio on monia sosioteknisiä ilmiöitä ja prosesseja, jotka liittyvät digitaalisten teknologioiden omaksumiseen ja käyttöön laajemmissa yksilöllisissä, organisaatioissa ja yhteiskunnallisissa yhteyksissä.
 - Trendi-ilmiö, joka siirtää talouden fyysisen maailman aikakaudelta virtuaalimaailmaan, joka perustuu digitalisointiteknologioihin (lähinnä Internetiin, "Big Dataan" ja mobiililaitteisiin).



Digitalisaatio edustaa muutosta ...

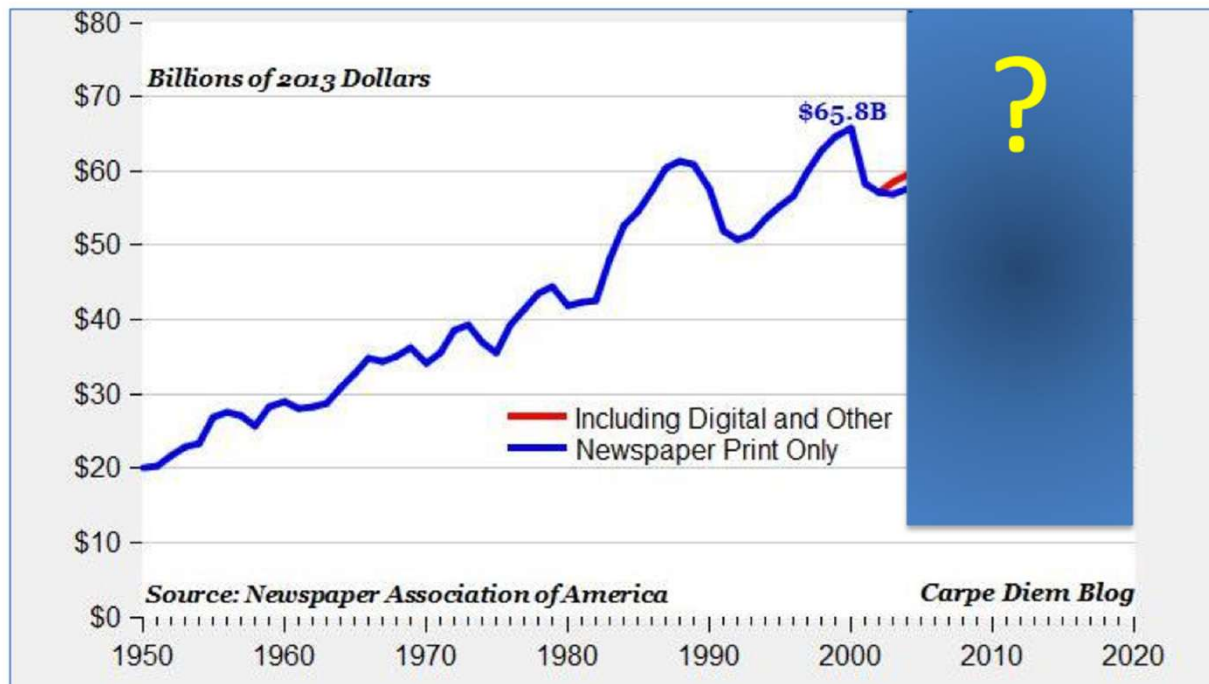
- Digitalisaation avaintekijä on **digitaaliset teknologiat (ICT, ohjelmistot)**.
- Digitalisaatio heijastaa digitaalisten teknologioiden käyttöönottoa **liike-elämässä ja yhteiskunnassa** sekä siihen liittyviä muutoksia yksilöiden, organisaatioiden ja objektien yhteyksissä
- Digitaalisten teknologioiden käyttöönoton ja käytön monenlaisia **sosioteknisiä ilmiöitä ja prosesseja** laajemmissa **yksilöllisissä, organisaatioissa ja yhteiskunnallisissa konteksteissa**.



Digitalisaation vaikutukset

Newspaper ad revenue

US Newspaper Advertising Revenue Adjusted for Inflation 1950 to 2014



Page 2



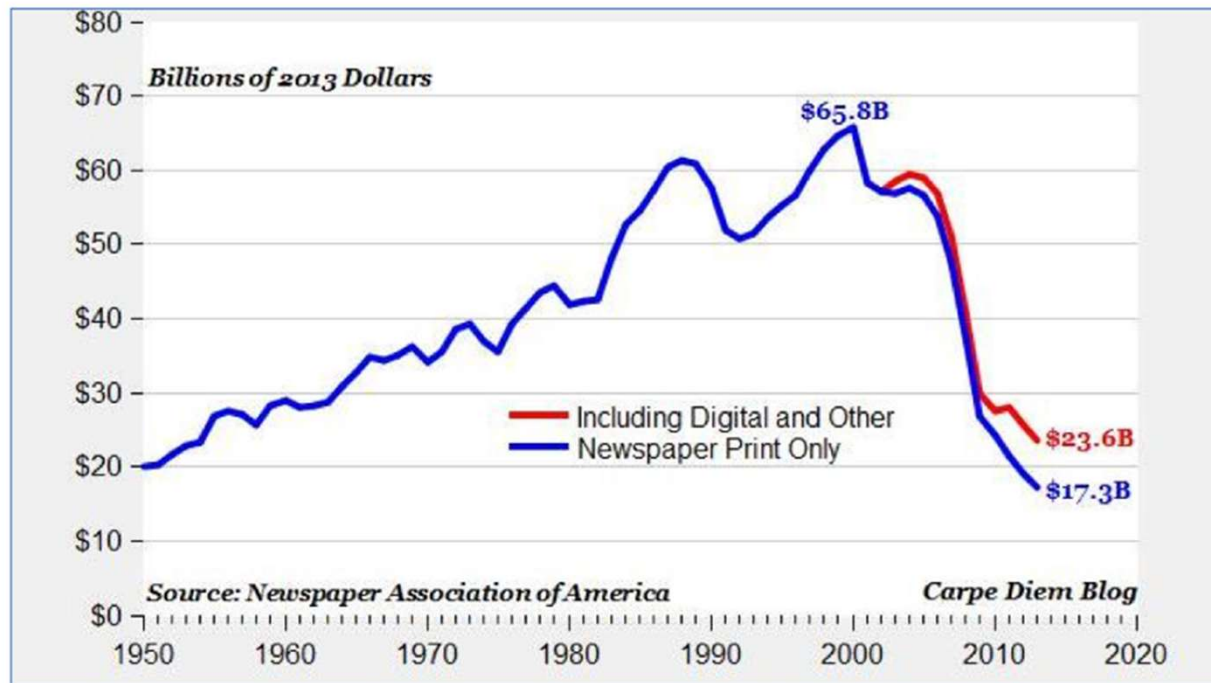
@dw2

Digitalisaation vaikutukset

Collapse of newspaper ad revenue

Page 3

US Newspaper Advertising Revenue Adjusted for Inflation 1950 to 2014



<http://www.aei-ideas.org/2014/04/creative-destruction-2013-newspaper-ad-revenue-continued-its-precipitous-free-fall-and-its-probably-not-over-yet/>

@dw2

Digitalisaation vaikutukset

- Muutos printtimediassa
 - Tiedon jakaminen ja levittäminen globaalia, kotimaisen median roolin muuttuminen
 - Sosiaalisen median vaikutus tiedon jakamiseen
 - Nopeus
 - Laajuus
 - Jos printtimedian tilaajat häviävät, häviävät myös mainostajat
 - mainostus verkossa
 - lukijamäärien todentaminen printti vs. verkko


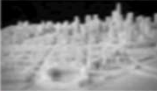

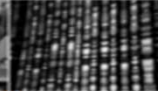

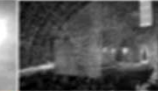


<https://www.mckinsey.com/~media/McKinsey/Business%20Functions/Organization/Our%20Insights/Unlocking%20success%20in%20digital%20transformations/Unlocking-success-in-digital-transformations.pdf>

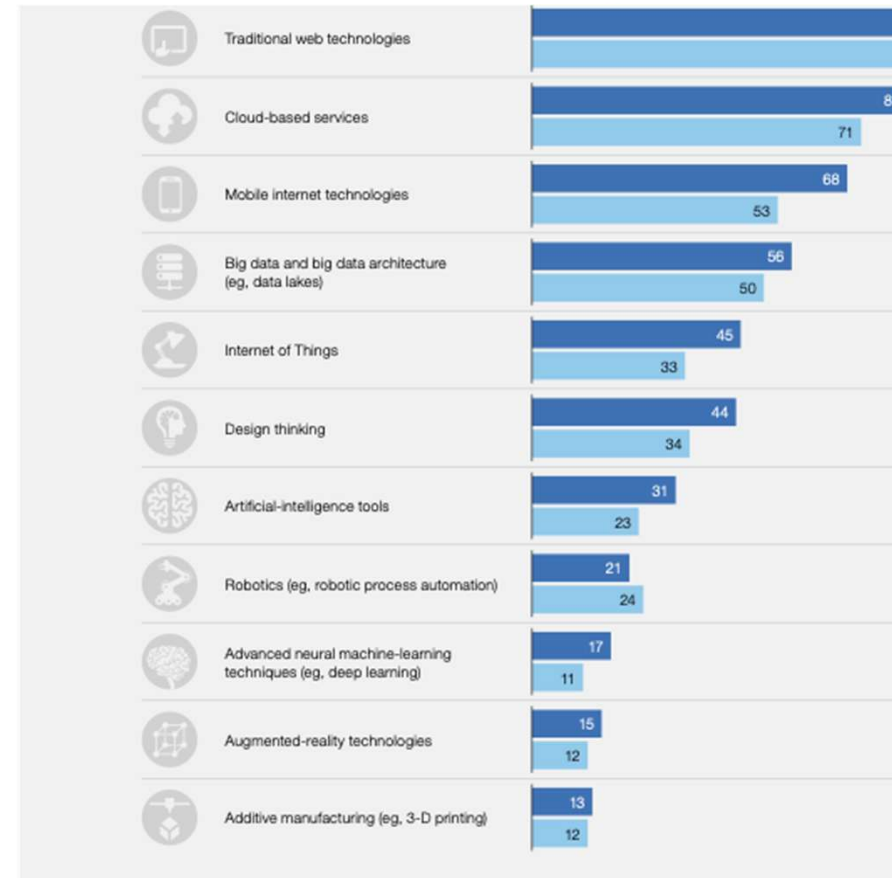


Teknologia mahdollistaa digitalisaation

- McKinsey global survey on digital transformations 2018
 - “Additionally, the adoption of technologies plays an important role across digital transformations.”
 - “...the results from successful transformations show that these organizations deploy more technologies than others do”

					
Drones cost per unit: - 2007: \$100k - 2013: \$700	3D printing cost averages for equivalent functionality: - 2007: \$40k - 2014: \$100	Industrial robots: - 2007: \$550k - 2014: \$20k	Costs for DNA sequencing: - 2000: \$2.7bn - 2007: \$10mn - 2014: \$1k	Solar power cost per kWh: - 1984: \$30 - 2014: \$0.16	Sensors (3D lidar): - 2009: \$30k - 2014: \$80

T. Ablyazov, J. Asaturova & V. Koscheyev (2018). Digital technologies: new forms and tools of business activity.

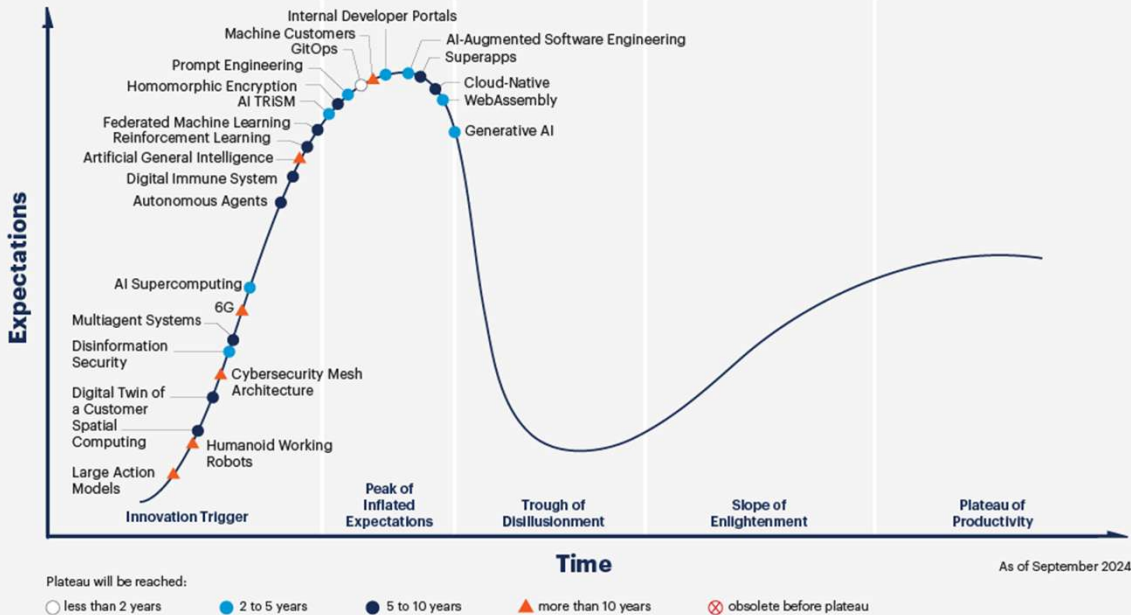


Unlocking success in digital transformation

Gartner Emerging Technologies 2024



Hype Cycle for Emerging Technologies, 2024



Source: Gartner
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Digitalisaation tavoiteltava lopputulos

Six Shared Global Outcomes to Achieve a Sustainable, Inclusive and Trustworthy Digital World



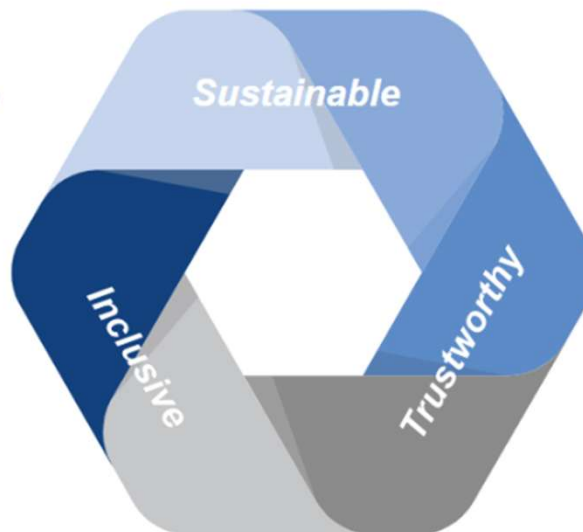
Access and Adoption
All people (without differences in geography, gender or income) can access and use the internet



Responsible Digital Transformation
Business, government and civil society leaders act responsibly and competently to usher in a sustainable digital transformation



Fit for purpose, informed governance
Global, regional, national policies are informed by evidence and well-equipped to deal with the transnational nature of digital connectivity



Secure and resilient people, processes and practices
All individuals, institutions and infrastructure are resilient to vulnerabilities created by increasing digital connectivity



User centric, interoperable digital identities
People can access and use inclusive, trusted digital identity regimes that enhance their social and economic well being



Trustworthy Data Innovation
Individuals and institutions can share data in ways that create social and economic value while respecting the privacy of fellow digital citizens

ICT käyttö eri aloilla



Digitalisaatiostrategiat

- Edellisen EU komission strategiset prioriteetit tähän kurssiin liittyen (https://ec.europa.eu/info/strategy_en):
 - A Europe fit for the digital age
 - European Green Deal
- A Europe fit for the digital age:
 - Erinomainen ja luotettava tekoäly
 - Euroopan datastrategia
 - Euroopan teollisuusstrategia
- European Green Deal:
 - Ilmastoneutraali 2050
 - Toimenpiteet - energiasektori, rakennukset, teollisuus, liikkuminen



Euroopan digitaalinen tulevaisuus

- Digitaalisen siirtymisen pitäisi toimia kaikille, asettaa ihmiset etusijalle ja avata uusia mahdollisuuksia yrityksille. Digitaaliset ratkaisut ovat avainasemassa myös ilmastonmuutoksen torjunnassa ja vihreään siirtymiseen.
- Tämän tekemiseksi EU korostaa
 - Tekniikkaa, joka **toimii ihmisille**
 - Reilua ja kilpailukykyistä **digitaalitaloutta**
 - Avointa, demokraattista ja kestäväää **yhteiskunta**



Euroopan vihreä siirtymä

- Digitaaliset teknologiat ovat ratkaisevan tärkeitä, jotta EU voi tulla ilmastoneutraaliksi vuoteen 2050 mennessä.
- ICT-sektorilla varsin suuri jalanjälki

Today the ICT sector accounts for:

5-9% of electricity use

more than 2% of global greenhouse gas emissions (as much as all air traffic).

If unchecked, the ICT footprint could increase to 14% of global emissions by 2040.



- Samaan aikaan teknologiat voivat auttaa
 - vähentämään päästöjä 7-kertaisesti
 - vähentämään globaaleja päästöjä 15%
- Green Deal huomioi useita eri sovellusalueita



Energy networks



Precision farming



Mobility and transport



Smart buildings



Green data spaces



The power of data

<https://op.europa.eu/en/publication-detail/-/publication/bd211835-5390-11ea-aece-01aa75ed71a1/language-en>



Green Deal tavoitteita



Climate change, the unprecedented loss of biodiversity, and the spread of devastating pandemics are sending a clear message: it is time to fix our broken relationship with nature.

Future EU integrated energy system : energy flows between users and producers, reducing wasted resources and money



▶ Buildings account for **40%** of energy consumed

Source: Eurostat, Energy balances 2019 edition, final energy consumption in year 2017.



New business models based on renting goods and services will help to shift **consumption patterns away from single or limited use products.**


Make sure Europeans get healthy, affordable and sustainable food


Tackle climate change


Protect the environment and preserve biodiversity


Fair economic return in the food chain


Increase organic farming



▶ **Go digital**

- **Automated mobility and smart traffic management systems** will make transport more efficient and cleaner.
- **Smart applications** and **'Mobility as a Service'** solutions will be developed.



EUn Green Deal (alkuperäiset kohteet)

- **Biologinen monimuotoisuus** – Toimenpiteet herkän ekosysteemimme suojelemiseksi
- **Maatilalta ruokapöytään** – tapoja varmistaa kestävämmät elintarvikejärjestelmät
- **Kestävä maatalous** - Kestävä kehitys EU:n maataloudessa ja maaseutualueilla
- **Puhdasta energiaa**
- **Kestävä teollisuus** – tapoja varmistaa kestävämmät, ympäristöä kunnioittavammat tuotantocyklit
- **Rakentaminen ja remontointi** - Tarve puhtaammalle rakennusallalle
- **Kestävä liikkuvuus** - Edistetään kestävämpiä liikennemuotoja
- **Saastumisen poistaminen** – Toimenpiteet saastumisen vähentämiseksi nopeasti ja tehokkaasti
- **Ilmastotoimet** – EU:n ilmastoneutraalius vuoteen 2050 mennessä

https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en



Digitalisaation soveltaminen

AgTech	Digital Supply Chain	Future Field Force	eHealth	Green Energy Tech	Industrial Transformation	Insurtech	Smart Buildings	Smart Cities	Smart Construction
Crop Management	Location Management and Route Optimisation	Field Force Management	Connected Medicine Dispensers	Smart Metering	Intralogsitics Optimisation	Claims Automation	Smart services	Smart Traffic Management	Worker Safety
Automatic Irrigation Systems	Condition Monitoring	Remote Monitoring	Remote Patient Monitoring	Microgeneration	X-as-a-Service	Associated Services	Smart security	Smart Streetlights	Site Security
Livestock Management	Supply Chain Transparency	Augmented Field Force	Clinical Environment Patient Monitoring	Energy storage	Worker Assistance	Parametric Insurance	Connected HVAC	Public Safety	Asset Tracking
Indoor Vertical Farming and Smart Greenhouses	Warehouse Management	Additive Manufacturing	Patient Data Management	EV charging	Quality Control and Assurance	Usage-Based (Automotive) Insurance	Smart doors and windows	Waste Management	Autonomous Construction
Drone Farming	Inventory Management		AI-based Diagnostic Solutions	Microgrids and VPPs	Additive Manufacturing	Improved Front Office Operations	Smart lighting	Environment Monitoring	Enhanced Project Efficiency
Farm Automation and Robots	Last Mile Delivery		Surgical Robots	Smart Grids	Brownfield Machine Monitoring	Improved Analytics	Air quality monitoring	Smart Mobility	Digitised Concrete Management
Farm Management	Supply Chain Planning and Operations		3D Printing	Digital Design & Planning	Environment Monitoring	Servitised Asset Insurance	User experience	Integrated Transport Systems	Next Generation Construction
Produce Monitoring			Asset Monitoring	Energy Trading		Supply Chain Insurance	Building Automation Systems	Smart Data Management	Digital Marketplace
Supply Monitoring						Smart Contracts	Smart vertical transportation	Wearable Cameras for Personal Protection	Enhanced Project Collaboration
							Water monitoring		

<https://www.vanillaplus.com/2024/01/10/85387-digital-transformation-from-an-end-user-perspective/>

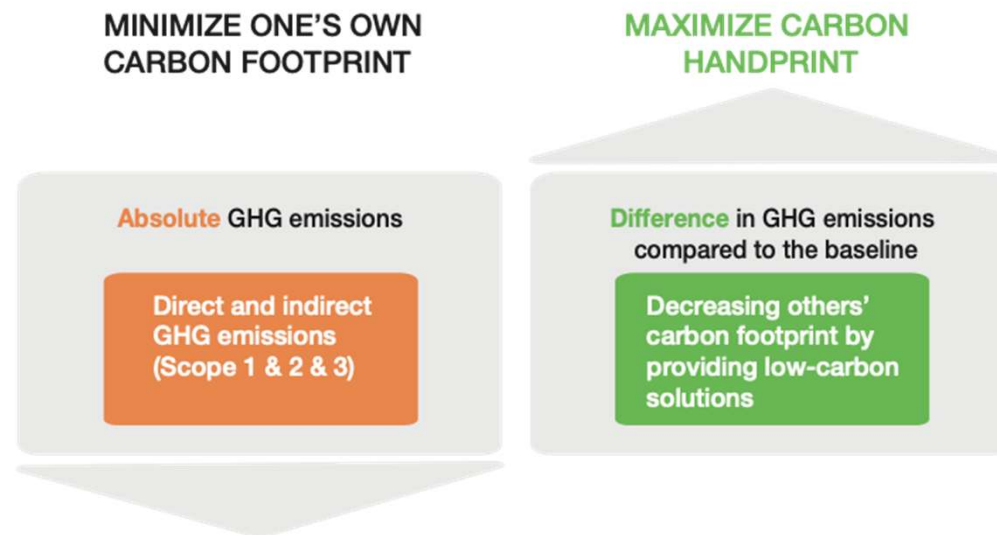


Kädenjälkivaikutukset

A small green plant with several leaves is growing out of a laptop keyboard. The background is a blurred laptop screen and keyboard. A green banner with white text is overlaid on the image.

Kädenjälki

- Kädenjäljellä tarkoitetaan hyödyllisiä ympäristövaikutuksia, joita organisaatiot voivat saavuttaa ja viestiä tarjoamalla tuotteita ja palveluita, jotka vähentävät muiden jalanjälkeä.
- Hiilikädenjälki on muiden hiilijalanjäljen pienentämistä.



**Carbon
handprint
guide**

V. 2.0
Applicable for environmental
handprint



[https://publications.vtt.fi/julkaisut/muut/2021/
Carbon_handprint_guide_2021.pdf](https://publications.vtt.fi/julkaisut/muut/2021/Carbon_handprint_guide_2021.pdf)

Mistä kädenjälki muodostuu

Less GHG intensive material use



Reduced waste and losses



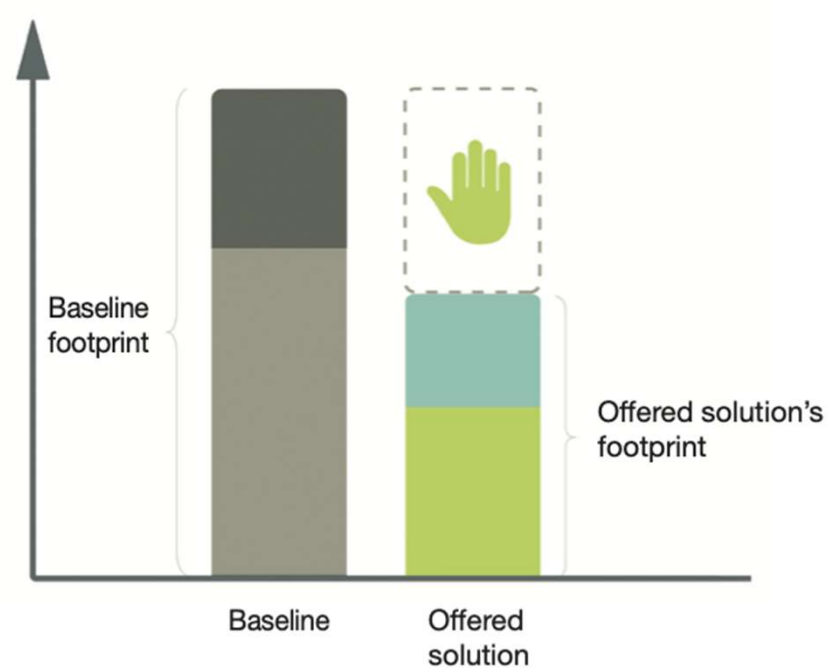
Less GHG intensive energy use



Increased carbon capture and storage



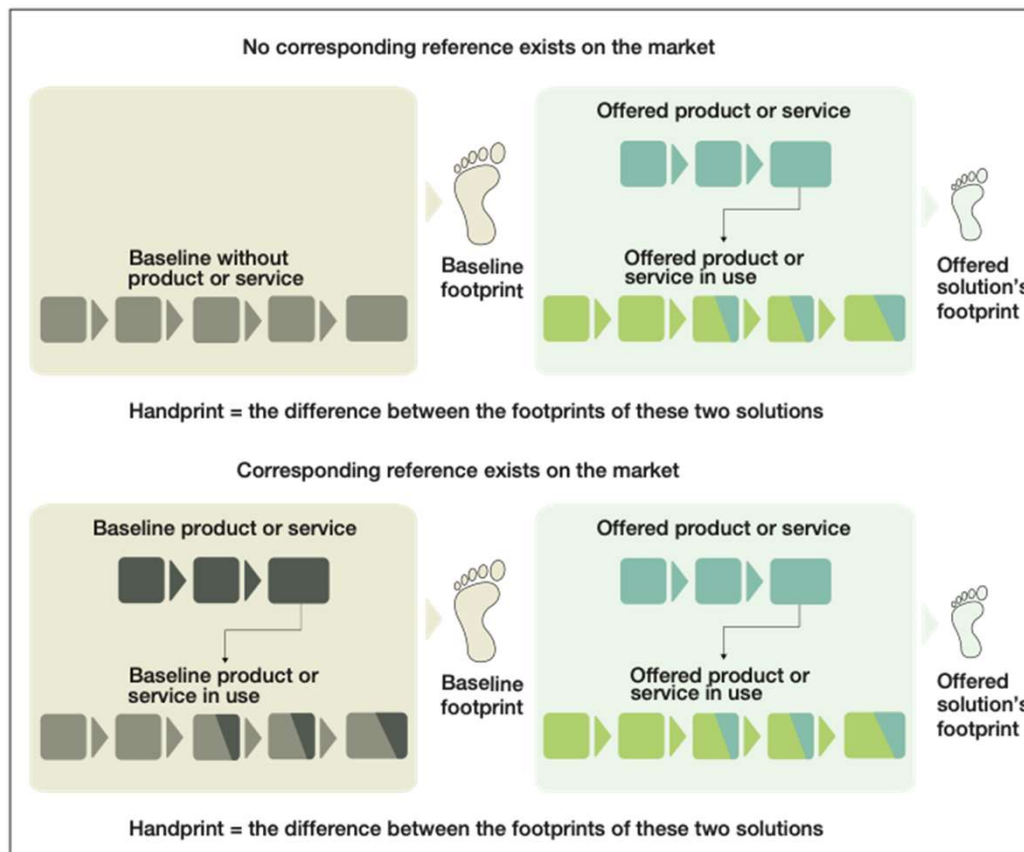
Increased lifetime and performance



https://publications.vtt.fi/julkaisut/muut/2021/Carbon_handprint_guide_2021.pdf



Kädenjälki vai jalanjälki?

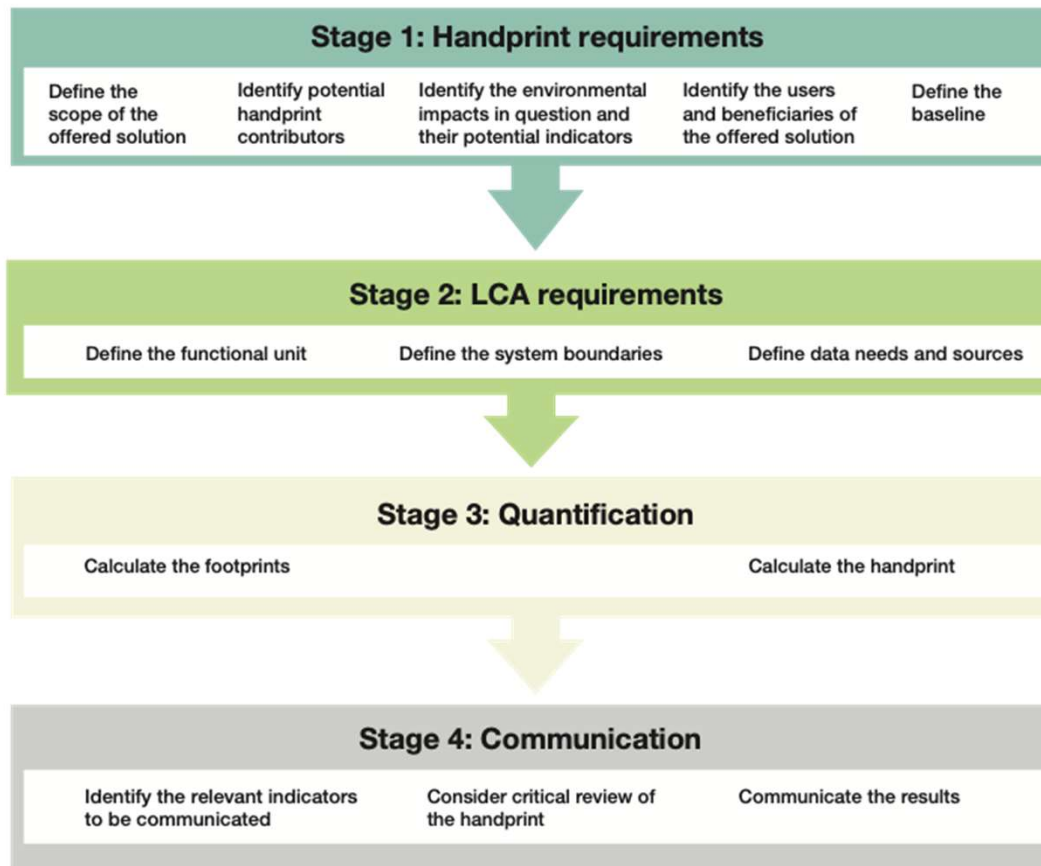


$$Handprint_{Product, service} = Footprint_{Baseline} - Footprint_{Offered solution}$$



https://publications.vtt.fi/julkaisut/muut/2021/Carbon_handprint_guide_2021.pdf

Kädenjäljen laskenta



https://publications.vtt.fi/julkaisut/muut/2021/Carbon_handprint_guide_2021.pdf

Esimerkki fyysisestä palvelusta

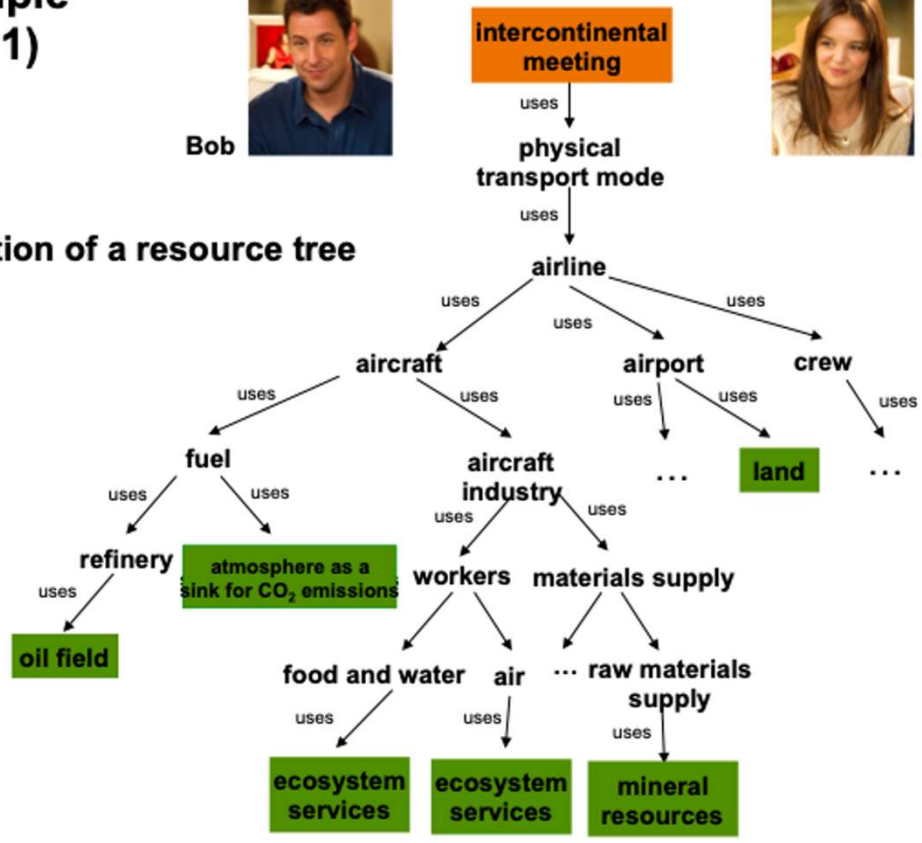
Example (Part 1)



Intercontinental meeting



Tiny portion of a resource tree

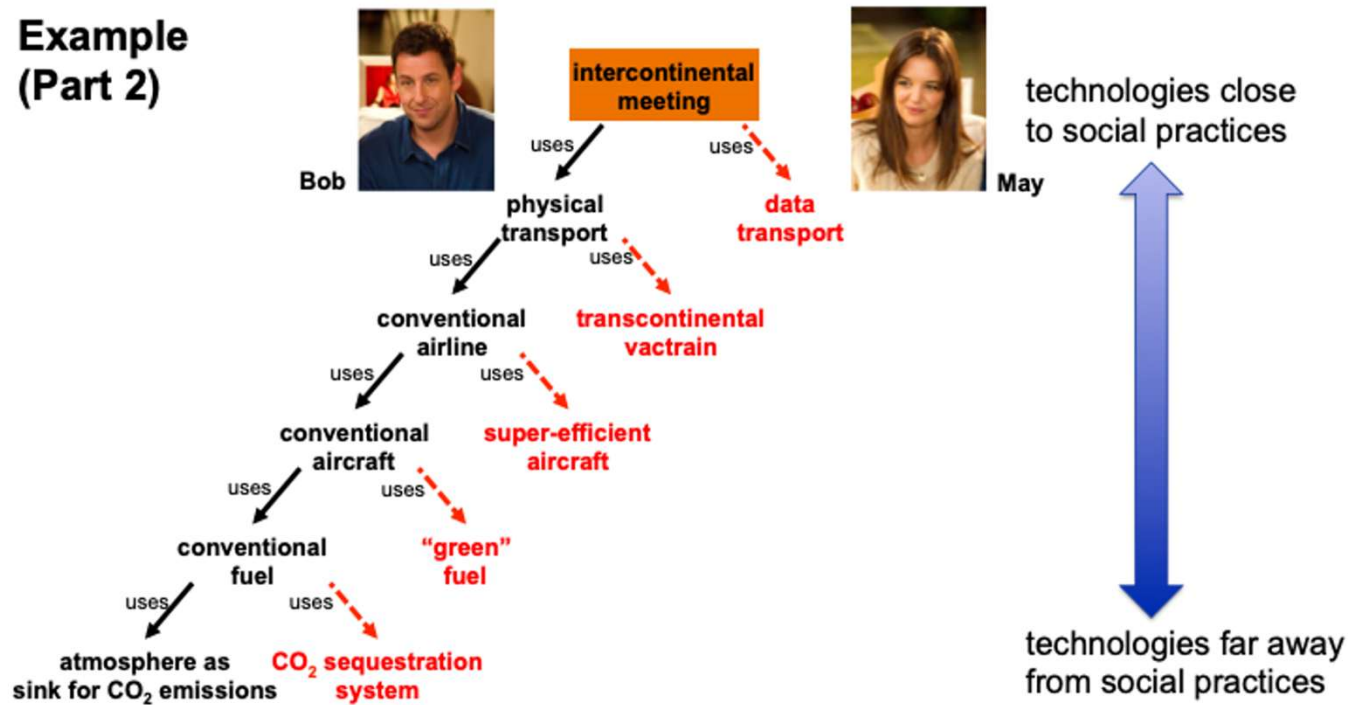


Slide by Lorenz Hilty, Keynote, ICT4S, 2014, Stockholm



Esimerkki fyysisen palvelun "vihertämisestä"

Example (Part 2)



A branch of the resource tree with potential technology substitutions
 Resource trees can be changed by technological substitution at any level

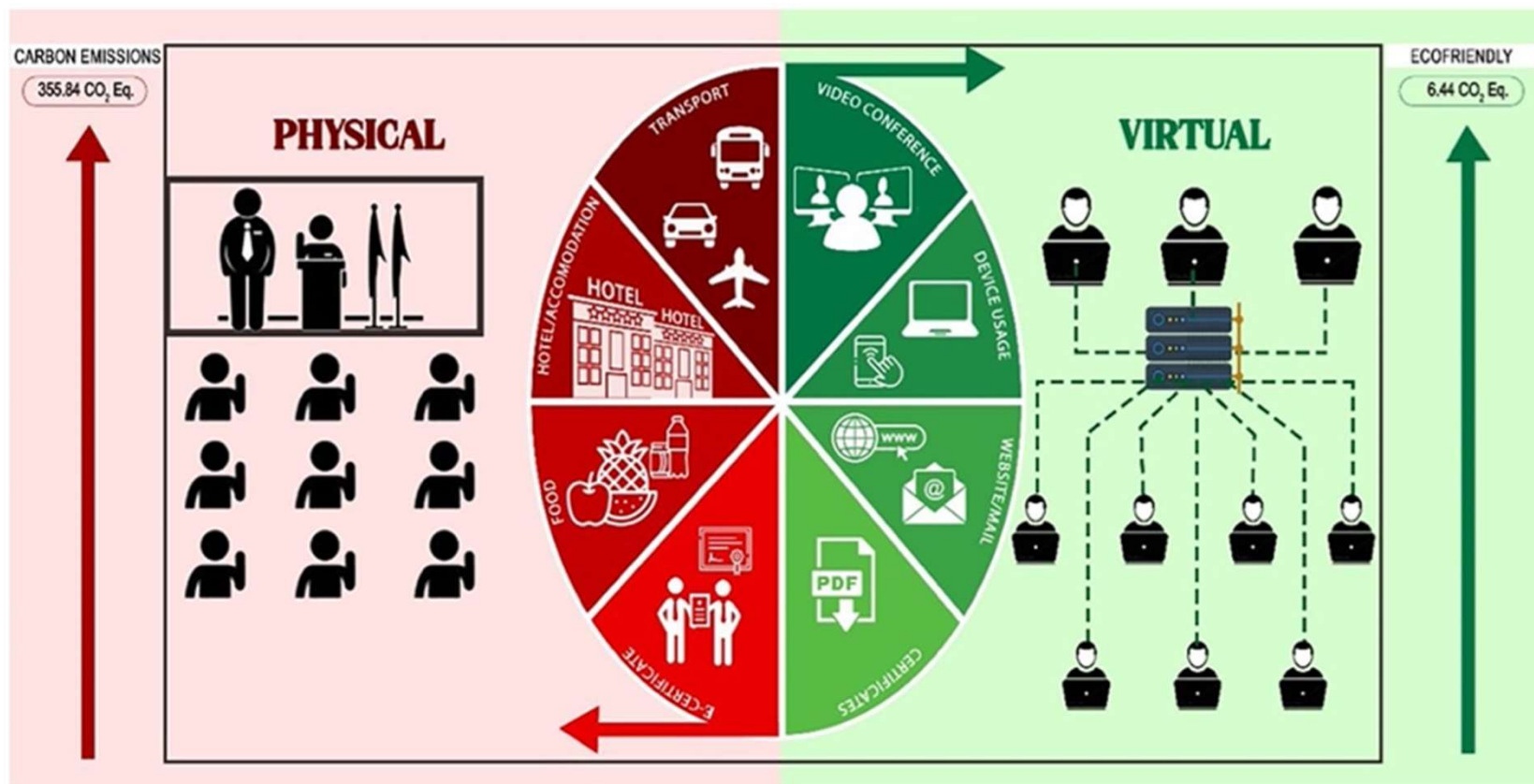


Esimerkki - Fyysisen palvelun digitalisointi

- Korvataan mannertenvälinen fyysinen tapaaminen verkkokokouksella
- Fyysisen palvelun jalanjälki (per henkilö)
 - Taksi lentokentälle 20km = 2,3kg CO₂
 - Mannertenvälinen lento (yksisuunta) = 750kg CO₂
 - Taksi kokouspaikalle 40km = 4,6kg CO₂
 - Kokoushuone (lämmitys, valaistus), tietokoneet 8h (n), paikallisverkko, ruokailu
 - + Paluu
- Digitaalisen palvelun jalanjälki (per henkilö)
 - Toimisto - lämmitys, valaistus (n)
 - Tietokone (n)
 - Paikallisverkko (n) + infrastruktuuri
 - Verkkopalvelu (zoom/teams) pilvessä



Esimerkki – konferenssin virtualisointi



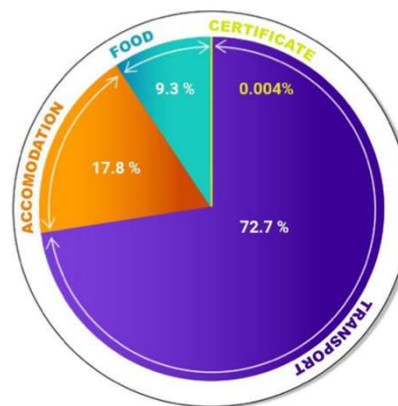
Periyasamy AG, Singh A, Ravindra K. Carbon Emissions from Virtual and Physical Modes of Conference and Prospects for Carbon Neutrality: An Analysis From India. *Air, Soil and Water Research*. 2022;15. doi:[10.1177/11786221221093298](https://doi.org/10.1177/11786221221093298)



Esimerkki - konferenssin virtualisointi (IAPSMCON 2021 – India, 2046 participants)

EMISSION HEADS	SCENARIO 1: HD STREAMING AND VIDEO SWITCHED ON DURING THE VC (CO ₂ EQ MT)	SCENARIO 2: SD STREAMING AND VIDEO SWITCHED OFF DURING THE VC (CO ₂ EQ MT)
Video Streaming	5.252	0.744
Emails	0.051	0.051
E certificates	0.003	0.003
Website Page Views	0.143	0.143
Device usage	0.980	0.980
Zoom server usage	0.013	0.013
Total	6.442	1.934
Per capita emission	0.004	0.001

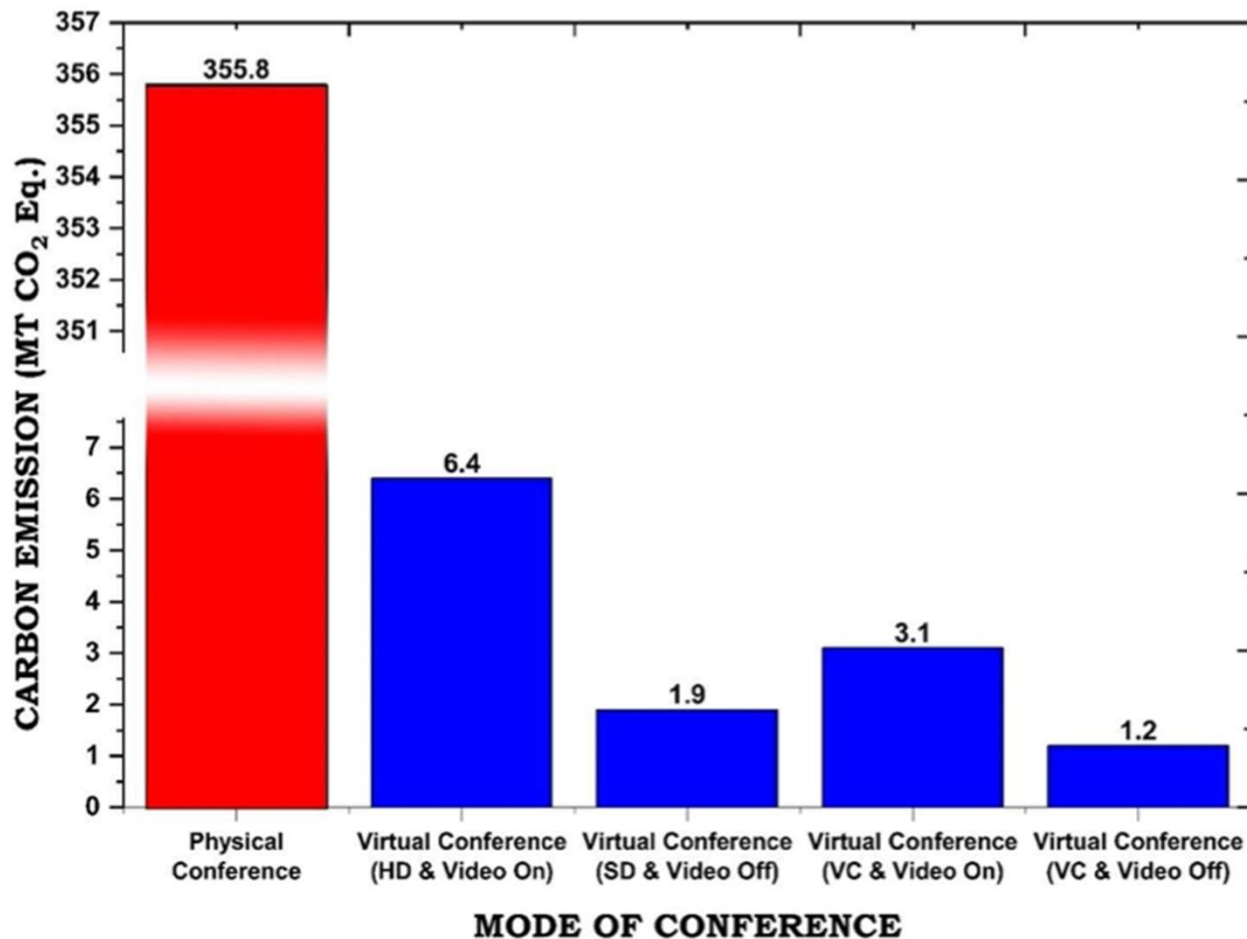
EMISSION HEADS	PHYSICAL MODE (CO ₂ EQ MT)
Transport	258.851
Accommodation	63.630
Certificates	0.015
Food	33.348
Total	355.843
Per capita emission	0.371



Periyasamy AG, Singh A, Ravindra K. Carbon Emissions from Virtual and Physical Modes of Conference and Prospects for Carbon Neutrality: An Analysis From India. *Air, Soil and Water Research*. 2022;15. doi:[10.1177/11786221221093298](https://doi.org/10.1177/11786221221093298)



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Air, Soil and Water Research. 2022;15.
doi:[10.1177/11786221221093298](https://doi.org/10.1177/11786221221093298)

Esimerkki – vertailu muihin konferensseihin

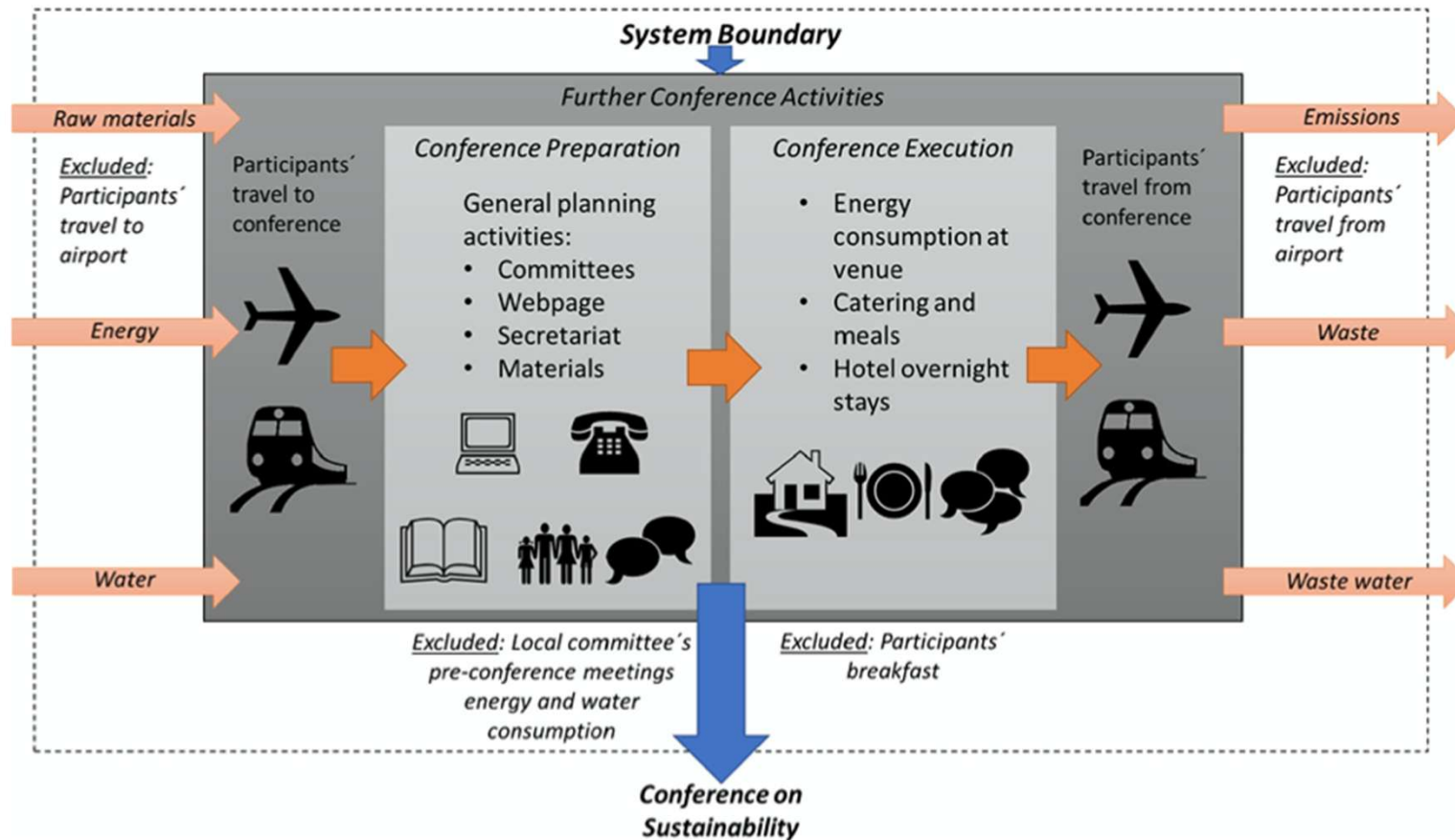


AUTHOR (YEAR OF PUBLICATION)	COUNTRY	CARBON EMISSION TOTAL MT CO ₂ EQ (PHYSICAL)	CARBON EMISSION PER CAPITA MT CO ₂ EQ (PHYSICAL)
Neugebauer et al. (2020)	Germany	455	0.57
Raby and Madden (2021)*	UK	234.7 (Physical) 1.1 (Virtual)	–
Desiere*	Slovenia	248-322	
Milford*	USA, Canada, and Czech Republic	–	0.31–0.93
van Ewijk*	USA	955	1.5
	UK	755	1.3
	South Korea	722	1.8
Wortzel et al. (2021)	USA	19,819–21,456	1.19–1.61

*Travel related carbon emission only.

Periyasamy AG, Singh A, Ravindra K. Carbon Emissions from Virtual and Physical Modes of Conference and Prospects for Carbon Neutrality: An Analysis From India. *Air, Soil and Water Research*. 2022;15. doi:[10.1177/11786221221093298](https://doi.org/10.1177/11786221221093298)

Toinen konferenssiesimerkki



S. Neugebauer, M. Bolz, R. Mankaa & M. Traverso (2020). How sustainable are sustainability conferences? – Comprehensive Life Cycle Assessment of an international conference series in Europe, Journal of Cleaner Production, Volume 242, <https://doi.org/10.1016/j.jclepro.2019.118516>.

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Origin of participants per continent.^a

Origin	Number of participants	Percentage
Africa	9	1.13%
Asia	43	5.38%
Europe	683	85.38%
Middle East	4	0.50%
North America	29	3.63%
Oceania	10	1.25%
South America	22	2.75%

^a Participants origin is derived from past conferences of the considered existing international conference series and assumed to be stable in close discussion with members of the permanent conference committee.

Activity	Specification	Value	Unit
Air travel	Passenger aircraft, intracontinental	391,843	pkm
	Passenger aircraft, intercontinental	922,561	pkm
	Total	1,314,404	pkm
Rail travel	High-speed train	150,251	pkm
	Regional train	30,480	pkm
	Total	180,731	pkm
Car travel	Passenger car, medium size, petrol, EURO 4	9,725	pkm
Bus travel	Regular bus	2,553	pkm

Means of travel per total distance, no. of participants, and overall percentage.

Means of travel per total distance, no. of participants and overall percentage ^a	Aircraft		Train	Car	Bus	Bicycle/foot
	Europe	From Outside of Europe				
Average distance, one way (km)	897	9165	326	122	21	5
Number of participants	270	117	325	70	8	10
Percentage of participants (%)	33.75	14.63	40.63	8.75	1	1.25

^a Air travel distances are calculated with www.greatcirclemapper.net; rail distance are calculated based on www.rail.cc; and car travel distances are calculated through www.googlemaps.com. The actual flight routes are determined by means of www.skyscanner.com assuming an average booking of two month in advance taking into account total travel time and price. The resulting number of intermediate stops is reflected in the assessment model.

Toinen konferenssiesimerkki

S. Neugebauer, M. Bolz, R. Mankaa & M. Traverso (2020). How sustainable are sustainability conferences? – Comprehensive Life Cycle Assessment of an international conference series in Europe, Journal of Cleaner Production, Volume 242, <https://doi.org/10.1016/j.jclepro.2019.118516>.

Activity	Specification	Value	Unit
Computer usage ^a	Laptop, 68% active work	112	h
	Laptop, 23% active work	112	h
	Laptop, standby/sleep mode	112	h
Printed matter ^a	Graphic paper, 100% recycled	1.05	kg
	Operation of printer, laser, black and white, per kg printed matter	1.05	kg
Paper waste disposal ^a	Waste paper	1.05	kg
Travel to Paris ^b	Passenger aircraft, intracontinental	19,780	pk
	Passenger train, high-speed	3,160	pk
	Regular bus	75	pk
	Taxi	75	kr
	Electricity consumption	198.14	kV
Hotel overnight stays ^c	Heat consumption ^d	464.63	kV
	Water usage/Wastewater treatment	3,906	l
	Waste generation	14	kg

Life Cycle Inventory of conference meeting rooms.

Activity ^a	Specification	Value	Unit
Electricity consumption	International Colloquium on Refractories	17,180	l
	Aachen Colloquium on Automobile and Engine Technology	29,880	l
	Conference under consideration	20,131	l
Thermal energy consumption ^b	International Colloquium on Refractories	4,630	l
	Aachen Colloquium on Automobile and Engine Technology	5,480	kWh
	Conference under consideration	4,653.5	kWh

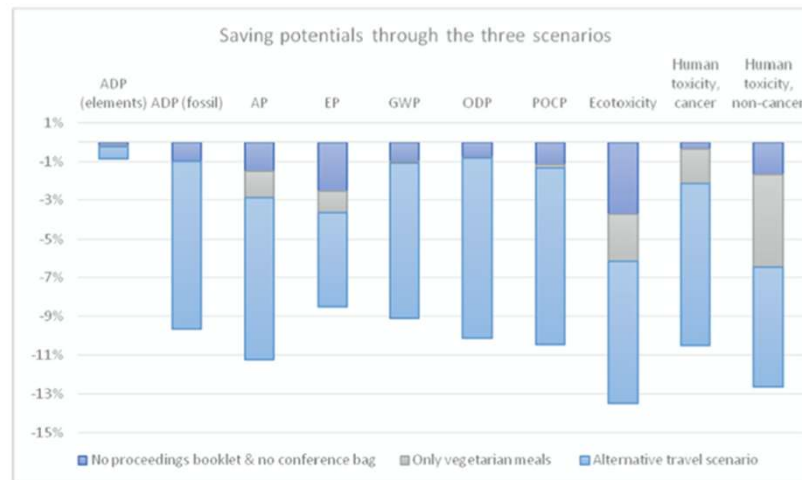
Life Cycle Inventory of the conference materials.

Activity	Specification	Value	Unit
Conference program	Paper, wood containing, supercalendered	309.11	kg
	Operation of printer, laser, colour, per kg printed matter	309.11	kg
Proceedings' booklet	Paper, wood containing, supercalendered	2,725.83	kg
	Operation of printer, laser, colour, per kg printed matter	2,725.83	kg
Jute bag ^a	Jute textile production	63.75	kg
	Transport, cargo aircraft, intercontinental	471.94	tkm
	Transport, freight, truck	19.13	tkm

Toinen konferenssiesimerkki

Total Life Cycle Impact Assessment results per impact category and conference stage.

Impact Category	Unit	Conference Preparation	Conference Execution	Further Conference Activities (Travel)	Total
Abiotic Depletion (ADP elements)	kg Sb eq.	0.07	6.91	0.19	7.16
Abiotic Depletion (ADP fossil)	MJ	133,036.66	750,855.75	5,317,471.94	6,201,364.35
Acidification Potential (AP)	kg SO2 eq.	50.77	165.85	1,405.70	1,622.32
Eutrophication Potential (EP)	kg Phosphate eq.	21.87	66.37	427.94	516.18
Global Warming Potential (GWP 100 years)	kg CO2 eq.	5,766.12	69,148.26	378,441.92	453,356.30
Global Warming Potential (GWP 100 years), excl. biogenic carbon	kg CO2 eq.	10,219.43	67,295.79	377,520.01	455,035.24
Ozone Layer Depletion Potential (ODP, steady state)	kg R11 eq.	0.0014	0.0007	0.0666	0.0686
Photochem Ozone Creation Potential (POCP)	kg Ethene eq.	3.84	12.77	133.79	150.40
Ecotoxicity (recommended only)	CTUe	296.79	5,248.45	1,263.64	6,808.89
Human toxicity, cancer (recommended only)	CTUh	0.000003	0.000040	0.000207	0.000250
Human toxicity, non-canc. (recommended only)	CTUh	0.000001	0.000012	0.000008	0.000020



S. Neugebauer, M. Bolz, R. Mankaa & M. Traverso (2020). How sustainable are sustainability conferences? – Comprehensive Life Cycle Assessment of an international conference series in Europe, *Journal of Cleaner Production*, Volume 242, <https://doi.org/10.1016/j.jclepro.2019.118516>.

ICT:n rooli - ympäristö

First order effects	Second order effects	Third order effects
Design and manufacture of ICT equipment <ul style="list-style-type: none"> - ICT production is a relatively lightweight industry - Use of toxic components - New waves of technology are more energy-efficient 	Increase and decrease in use of transport <ul style="list-style-type: none"> - Increase in home deliveries as a result of E-commerce will have significant environmental impact unless well co-ordinated - Telework reduces travel miles for employees - Telematics reduces traffic congestion, journey times and therefore pollution - Rebound effects from increased leisure travel 	De-coupling economic growth and energy consumption <ul style="list-style-type: none"> - Possibilities of reducing energy used per unit GDP
Operation of ICT equipment <ul style="list-style-type: none"> - Energy use even in stand-by mode 	ICT in business systems <ul style="list-style-type: none"> - B2B E-commerce and ICT-managed control systems create efficiencies and reduce environmental impact 	De-coupling economic growth and carbon emissions <ul style="list-style-type: none"> - Possibilities of reducing carbon dioxide emissions per unit GDP
Disposal of ICT equipment <ul style="list-style-type: none"> - Problematic disposal - Recycling and safer designs increasing 	Virtualisation of material products <ul style="list-style-type: none"> - Possible environmental savings from increased trade in intangibles 	Changing settlement patterns <ul style="list-style-type: none"> - Conflicting pressures on local settlement - Possible increase in environmental pressure on regions
	Effects on product lifetimes <ul style="list-style-type: none"> - Some E-commerce business models extend product lifetimes - Product development cycles are often reduced by use of ICT 	
	Distribution and manipulation of environmental information <ul style="list-style-type: none"> - Significantly enhanced by ICT 	



ICT:n rooli – yhteiskunta

First order effects	Second order effects	Third order effects
Job creation - Jobs created in production of ICT equipment	Access to information - Health information available online - Government information available online	Cultural homogeneity or cultural diversity? - ICT promotes homogeneity and diversity at the same time
Digital divide - Discrepancies in distribution of access to ICT	Security challenges - Risk to users of Internet - Internet also used by criminal groups	Building local communities - ICT may bolster local communities
	Access to better services - Health services, E-learning, Government services, E-commerce and telework create opportunities for social inclusion	Building civic culture - ICT may encourage popular participation in community affairs
	New communities online - Internet enables new types of community	
	Popular protest online - Internet enables new types of protest	



ICT:n rooli – talous

First order effects	Second order effects	Third order effects
Growth of the ICT market - Size of sector and numbers employed	Application of ICT within businesses - ICT creates opportunities for new efficiencies in business	ICT and the “new economy”: a new paradigm of growth? - Long-term and fundamental changes to the global economy may create a more beneficial environment for the goals of sustainable development
Ongoing investment in ICT - Investment in technology within companies continues to grow	New opportunities for SMEs - New markets and more efficient production for SMEs	Exclusion or inclusion? - The globalised economy may reinforce uneven patterns of wealth - ICT may provide new solutions to ensure economic benefits are shared
Ongoing investment in ICT research and development - Resources continue to be ploughed into developing new technologies	Financial markets - ICT enables new financial markets, creating growth - ICT enables wider participation in financial markets	
New types of company - Changing the structure of the economy	The relationship between business and the market - Consumers are empowered - Companies are encouraged to act ethically	
Boom and bust - Market volatility		



ICT:n vaikutukset ei mikään uusi asia

European Information Technology Observatory - EITO 2002

250

The impact of ICT on sustainable development

This paper has been provided by Forum for the Future in close co-operation with the EITO Task Force.

1. General overview

The chapter aims to:

- introduce the concept of sustainable development;
- examine the impacts and opportunities created for sustainable development by the rapid penetration of ICT into society and culture;
- suggest the means for mitigating adverse affects and encouraging positive outcomes for all in the penetration of ICT.

An innovative framework has been developed that allows a detailed and comprehensive analysis of the environmental, social and economic effects and opportunities of ICT in the context of sustainable development.

The chapter will conclude that in some cases ICT is of direct benefit to the goals of sustainable development, and in others detrimental. In most cases, however, the overall effects will only become clear in the medium to long term.

It is shown that despite its great potential, ICT is not in itself a force for sustainable development, but has both positive and negative effects. In order to maximise the positive effects and minimise the negative, the development and application of ICT should be guided by policy makers in government, business and civil society.

2. What is sustainable development?

Although there are many definitions of sustainable development, the most commonly quoted comes from the Brundtland Commission's 1987 report, "Our Common Future". Here, sustainable development is defined as "development which meets the need of the present without compromising the ability of future generations to meet their own needs".¹

This chapter defines sustainable development as:

*A dynamic process which enables all people to realise their potential and improve their quality of life in ways that simultaneously protect and enhance the Earth's life-support systems.*²

Implicit here is that economic, social and environmental dimensions are equally vital and inter-connected:

- *Economic* sustainability means economic growth without making undue demands on social or natural resources.
- *Environmental* sustainability means not only minimising impacts on the environment, but building natural resources and safeguarding them for the future.
- *Social* sustainability means building, and not undermining, social equity.

¹ Brundtland Commission, "Our common Future", 1987

² Forum for the Future definition of sustainable development.



Global eSustainability Initiative



#SMARTer2030

ICT Solutions for 21st Century Challenges

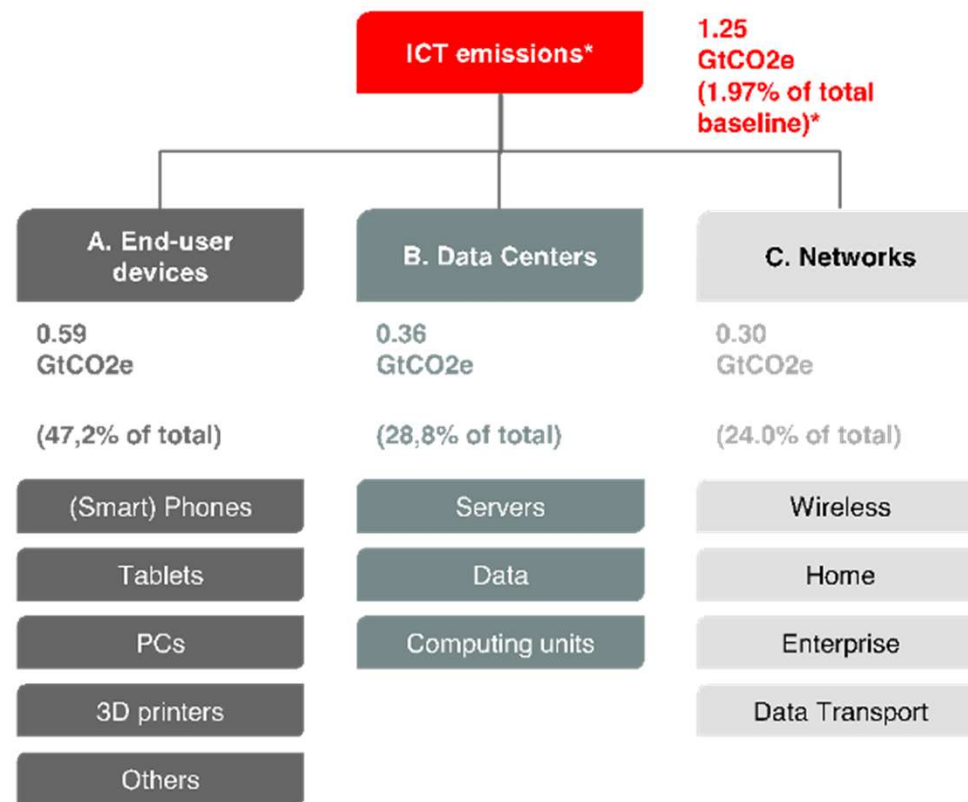


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


ICT:n jalanjälki

- "Laitteiden, kuten tablettien ja älypuhelimien, sekä palvelujen, kuten pilvipalvelun, laajakaistaverkkojen ja datakeskusten, käyttöön oton nopea lisääntyminen johtaa ICT:n lisäpäästöihin."
- Digitalisaatio ja digitaalisten palveluiden käyttö vauhdittavat tätä kehitystä
- On tärkeää tehdä ICT:stä mahdollisimman tehokas



ICT:n hyödyntäminen eri alueilla

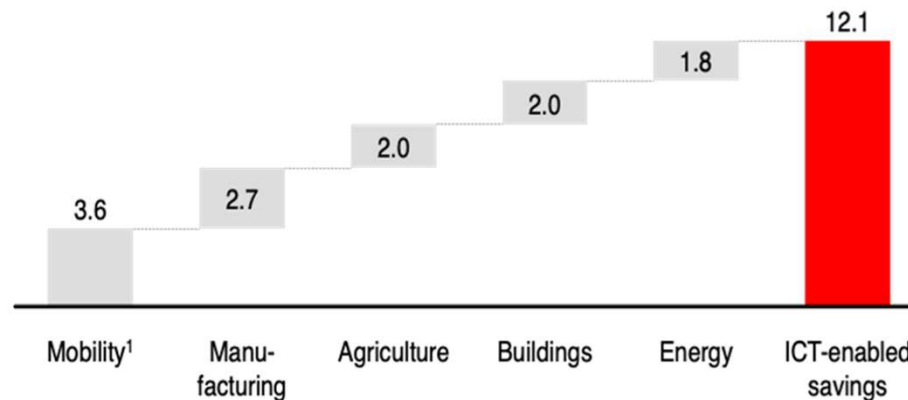
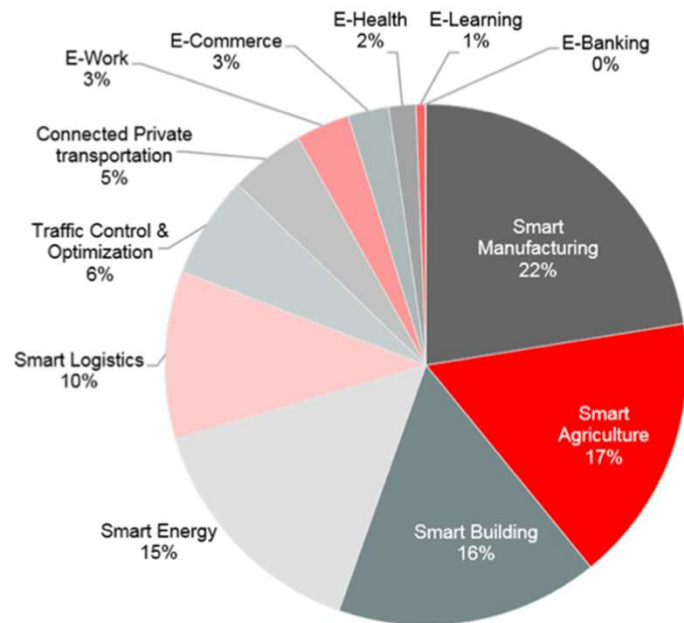
 <p>Energy: <i>ICT can enable the integration of renewables onto the grid, improve efficiency and heighten transparency.</i></p> <p>Smart Grids, analytics solutions and advanced energy management systems can abate 1.8Gt CO_{2e} and generate \$0.8 trillion in new revenue opportunities.</p>	 <p>Food: <i>ICT can help raise productivity and reduce food waste.</i></p> <p>Smart Agriculture will boost yields by 30%, avoid 20% of food waste and could deliver economic benefits worth \$1.9 trillion. At the same time, Smart Agriculture could reduce water needs by 250 trillion liters and abate 2.0Gt CO_{2e}.</p>
 <p>Health: <i>ICT will put "a doctor in your pocket," allowing users to manage their own health via their smart device.</i></p> <p>ICT could deliver E-Health services to 1.6 billion people across the developing and developed world.</p>	 <p>Learning: <i>ICT can make education accessible, engaging, flexible and affordable.</i></p> <p>We expect to see 450 million E-Learning participants in 2030, helping to raise incomes by 11% on average per e-degree.</p>
 <p>Buildings: <i>ICT will increase comfort and reduce energy and water bills.</i></p> <p>Smart building solutions could cut 2.0Gt CO_{2e} from the housing sector, reducing energy costs by \$0.4 trillion and creating revenue opportunities of \$0.4 trillion.</p>	 <p>Mobility & Logistics: <i>ICT can help everyone reach their destinations faster, cheaper and safer.</i></p> <p>Real-time traffic information, smart logistics, intelligent lighting and other ICT enabled solutions could abate 3.6Gt CO_{2e}, including abatement from avoided travel.</p>
 <p>Work & Business: <i>ICT-enabled telecommuting and virtual conferencing can save employees time and money</i></p> <p>Additional revenues from e-commerce could total \$1.8 trillion and E-Work could add \$0.5 trillion while freeing up 100 hours per E-Worker annually.</p>	 <p>Manufacturing: <i>ICT will place the customer at the center of a user focused service, cutting resource inputs at the same time</i></p> <p>Smart manufacturing, including virtual manufacturing, customer centric production, circular supply chains and smart services could abate 2.7Gt CO_{2e}.</p>



GeSI, SMARTer2030 (2015)
https://smarter2030.gesi.org/downloads/Full_report.pdf

ICT:n kädenjälki

- GeSI #SMARTer2030 arvioi kahdeksan alan kestävyysvaikutuksia (ei vain ympäristövaikutuksia)

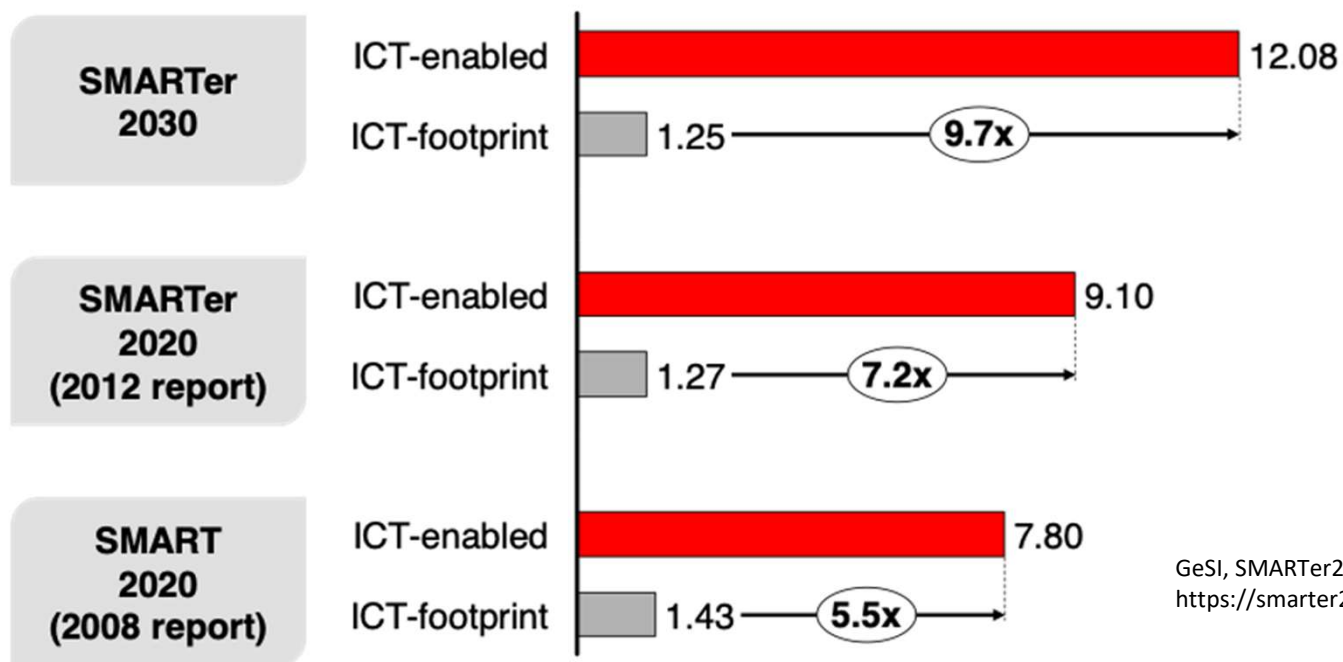


GeSI, SMARTer2030 (2015)
https://smarter2030.gesi.org/downloads/Full_report.pdf



Jalanjälki vs. kädenjälki

- Digitalisaatio (erityisesti ohjelmistot) mahdollistaa suuren kädenjäljen

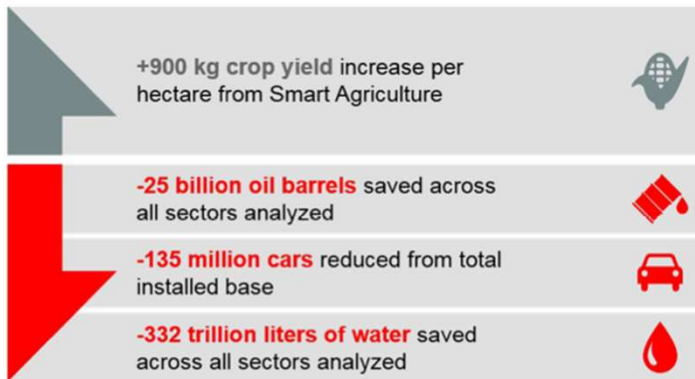


Source: Source: WRI, IPCC, GeSI, SMARTer2020, Accenture analysis & CO2 models

GeSI, SMARTer2030 (2015)
https://smarter2030.gesi.org/downloads/Full_report.pdf

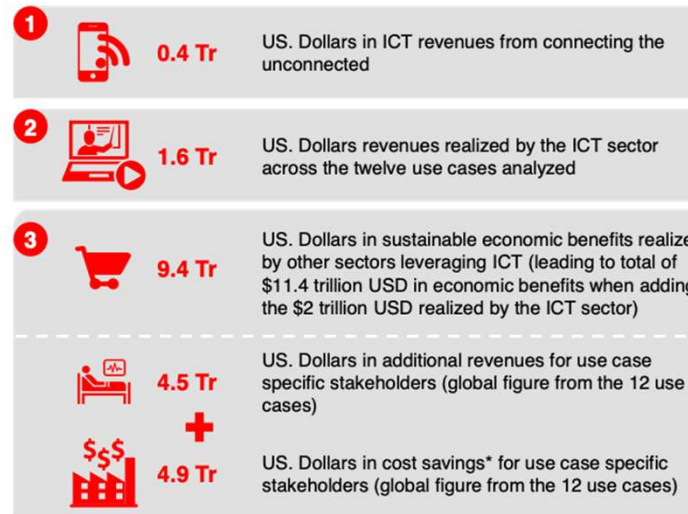


ICT:n hyödyt ovat moniulotteisia



Use Case-specific metrics

- 1** **1.6 Bn** People with access to E-Health
- 2** **450 Mn** E-Learning participants in 2030 (secondary education students, higher education students and company training participants)



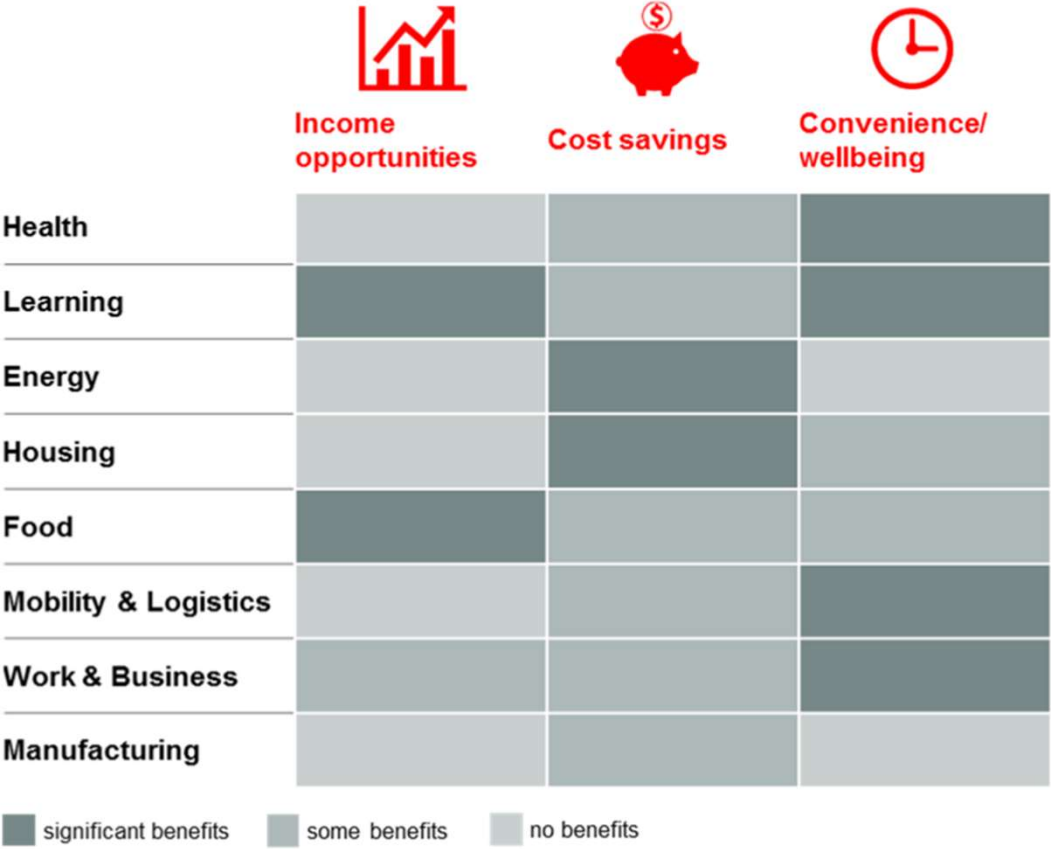
Global aggregated metrics

- 1** **2.5 Bn** People gaining ICT access
- 2** **254 Bn** Hours saved across multiple Use Cases

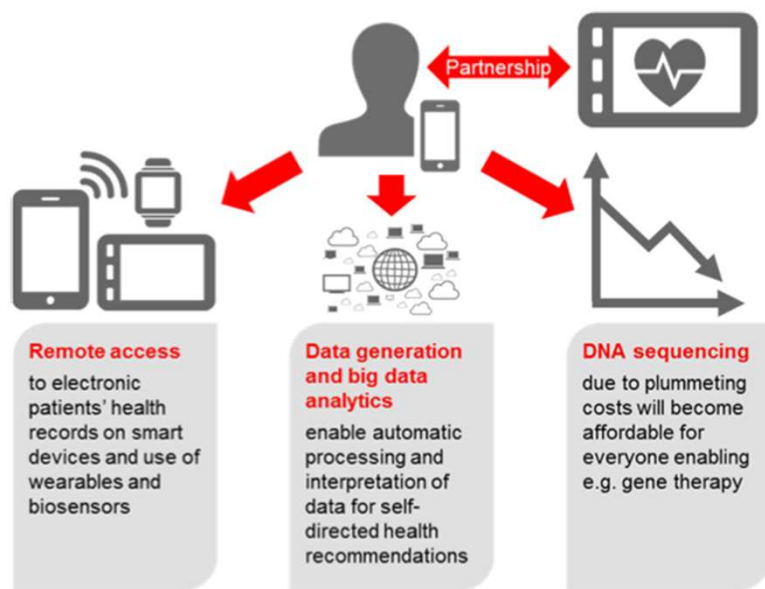
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ICT:n hyödyt ovat moniulotteisia - sosiaalinen dimensio

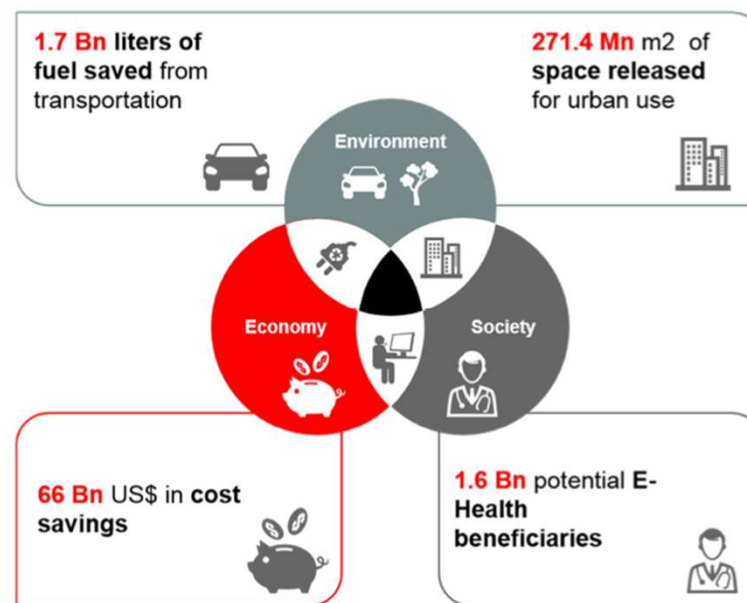


Terveydenhuolto

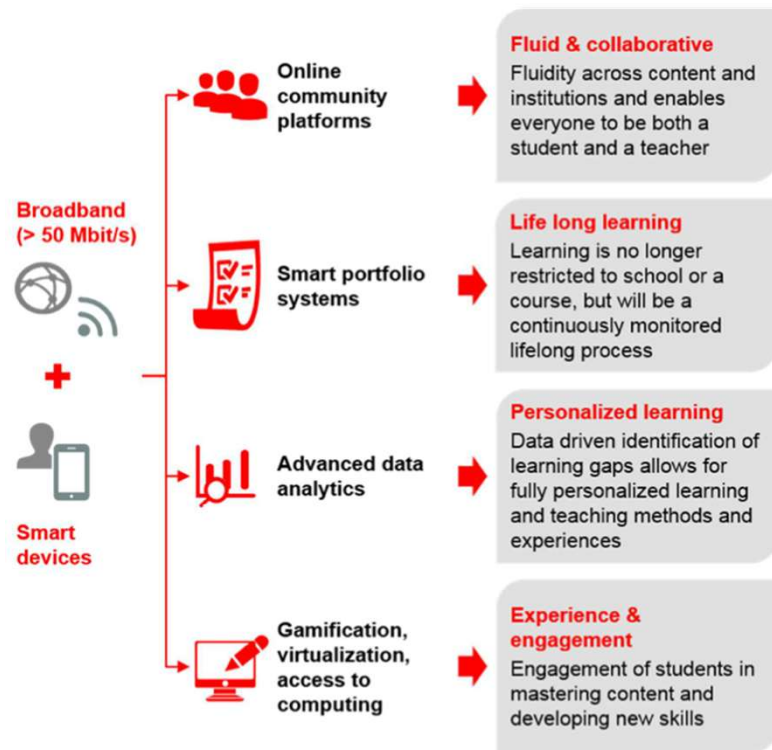


- Etädiagnostiikka
- Videovastaanotto
- Data
- Lisätty todellisuus

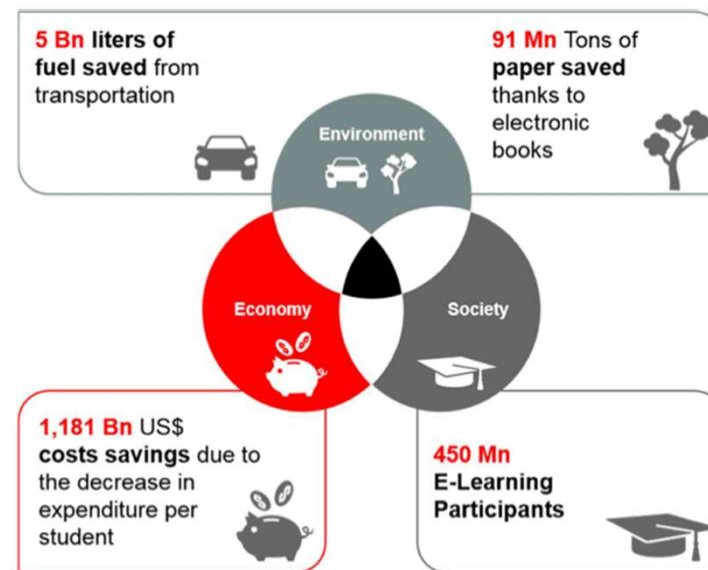
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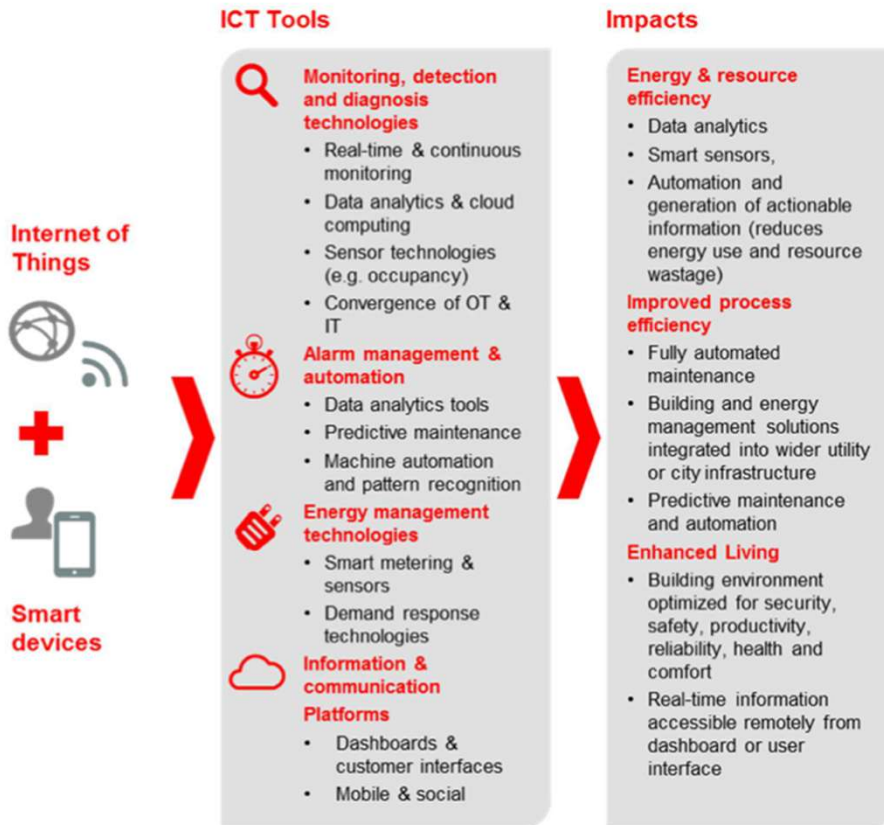
Koulutus



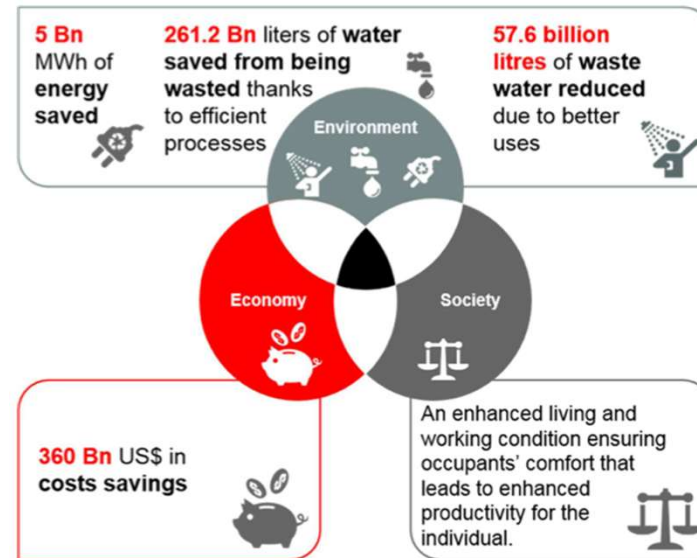
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Rakennukset



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Maatalous



Precision agriculture

- **Connectivity between machines and equipment**
- **Sensors and satellites**
- **Advanced data analytics**
- **ICT enabled processing of genomic sequencing** of livestock, seeds and plants



Resource efficiency

Monitoring, tracking, real-time data and the right information to the right people via mobile apps or messaging enhances resource efficiency (water, fertilizer, nutrition, equipment, etc.)

Broadband (> 50 Mbit/s)



Information & communication platforms

Online platforms and apps that collect data and transform it into meaningful information, communication and decision-making support.



Food waste prevention

Tracking, data-centric decision-making processes based on real-time data and the right information throughout the food chain reducing food waste at production, distribution & consumption.



Smart devices



Farm management technologies

Automation and optimization of general farm management practices and back-office IT



Enhanced productivity

Higher crop yield and income potential by enhanced farm management technologies, e.g. monitoring soil and livestock, forecasting, early detection of problems.



Traceability and tracking systems

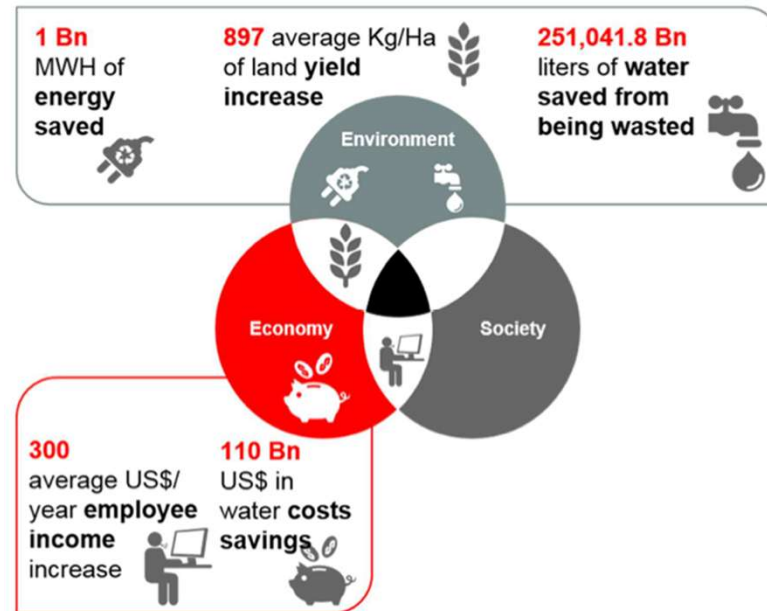
Smart logistics (RFID, GPS) allow better tracking of food as it is stored and transported and tracking of equipment throughout lifecycle or food chain



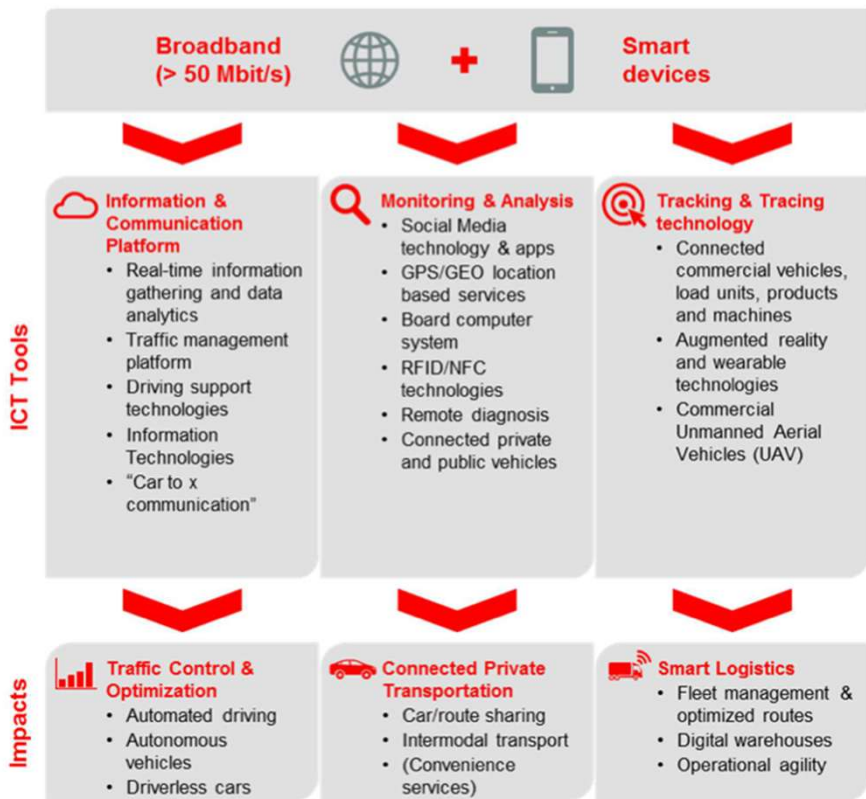
Shock resilience

Advanced analytics and forecasting allow for preventive cautions to environmental shocks and build resilience

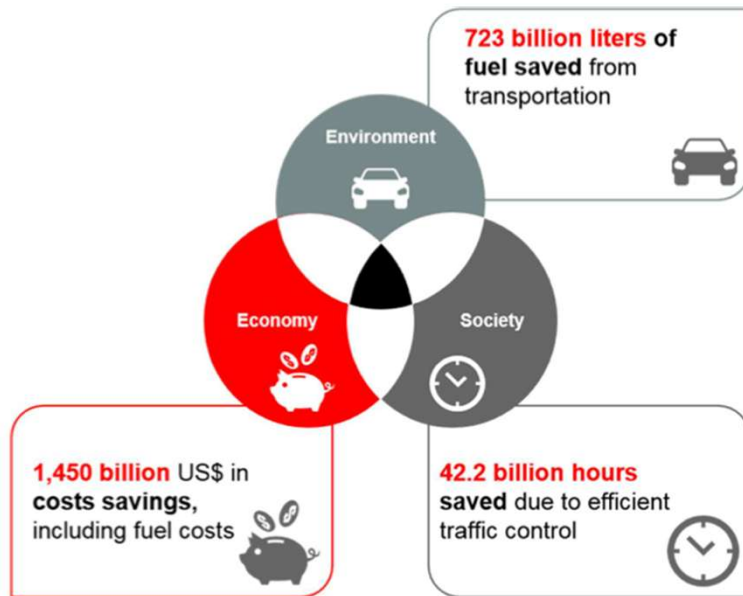
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Liikkuminen/logistiikka



GeSI, SMARTer2030 (2015)
https://smarter2030.gesi.org/downloads/Full_report.pdf



Energiasektori

ICT Tools

Convergence of IT/OT
Integration of Operations Technology (OT) – enterprise technology used to monitor and control physical devices, assets and processes – and Information Technology (IT)

Distribution management system
Two-way flow of information, component management and sensor technologies

Demand response technologies (B2B, B2C)
Technologies using real-time information to better match supply and demand (load management); incentives to shift demand

Advanced analytics
Modelling support, real-time system analytics, forecasting, predicting and contingency analysis

Energy storage technology
Help to manage power supply

Impacts

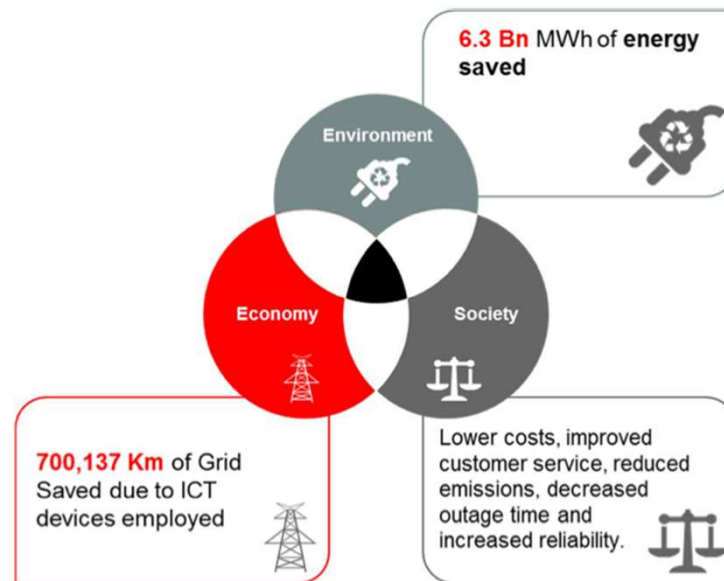
Improved load management
Real-time demand response technologies flattens out demand curve, decreases system load by better supply & demand matching

Enablement of renewables
Improved load management allows better integration of variable and distributed energy (e.g. in microgrids).

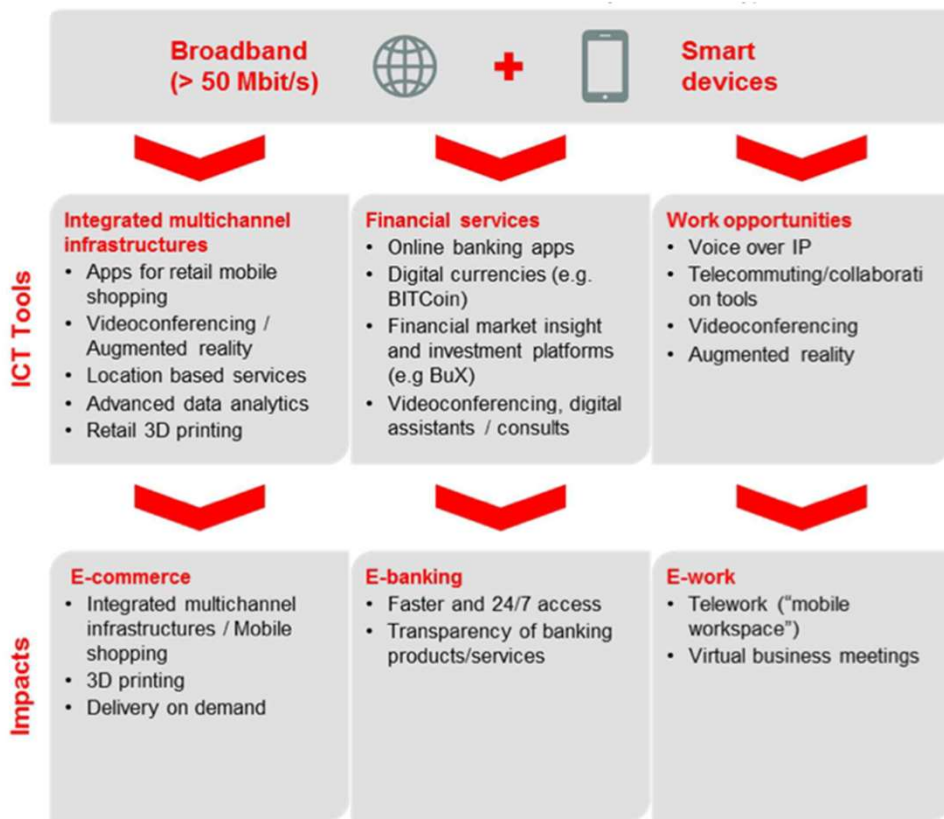
Grid efficiency
Improved load management and remote optimization of assets/ operations through grid monitoring result in **lower efficiency losses** during transmission, storage and/or distribution.

Resilient energy infrastructure
Improved management of power supply and peak loads through energy storage creates a more resilient grid.

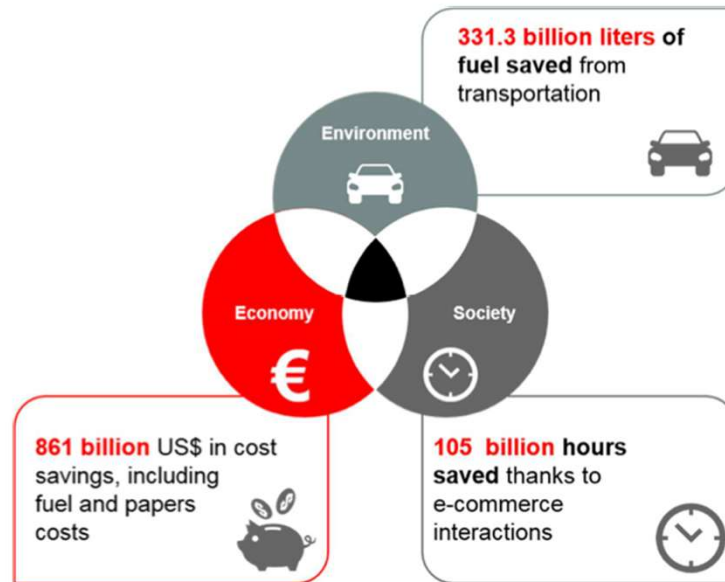
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e-business



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Valmistava teollisuus

ICT Tools

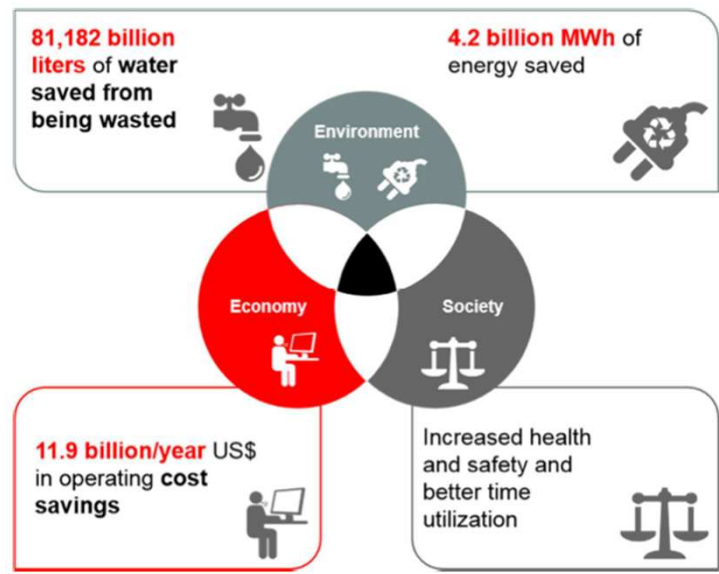
- Cyber-physical systems (CPS)
- Industrial Internet of Things (IIoT)1 and M2M
- Embedded system production technology
- Global network
- Data analytics & cloud computing
- 3-D printing
- Drones & Robotics
- Augmented reality devices

Impacts

- Virtual Manufacturing**
 - CPS combined with IIoT/M2M and advanced data analytics allows e.g.:
 - Remote monitoring of physical processes,
 - Real-time communication and cooperation
 - Performance management and continuous refinement of processes.
- Customer-centric production**
 - Integrating customer preferences in development and production processes,
 - Decentralized production networks / distributed manufacturing
- Circular Supply Chain**
 - Remanufacturing of products, components, and waste; circular packaging.
- Smart services**
 - Creation of a cross-sector ecosystem of services with up- and downstream integration.

- ↑ Productivity Quality
- ↑ Flexibility
- ↑ Resource Efficiency
- ↑ Value

GeSI, SMARTer2030 (2015)
https://smarter2030.gesi.org/downloads/Full_report.pdf



Digitalisaatio vaikuttaa myös

- SDG:n 169 tavoitteesta digitaalitekniikat vaikuttavat suoraan 103:een.
 - 20 tavoitteen ja niiden indikaattorien analyysi osoittaa, että nykyisten digitaalitekniikoiden odotettu käyttöönotto auttaa nopeuttamaan edistymistä keskimäärin 22 prosenttia.



1. Digital Access: connectivity for people to people, and people to the internet;



3. Cloud: the provision of highly scalable, advanced IT capabilities as 3rd party services;



5. Cognitive: the application of advanced analytics, machine learning and artificial intelligence approaches to big data to develop insight;



7. Blockchain: a system of digital, distributed ledgers of transactions comprising a database of information, with an append-only structure, governed by a network of computers instead of a central party.



2. Fast Internet: next generation connectivity, personified by 5G, that provides speed and capacity at fundamentally different levels;



4. IoT (Internet of Things): the connecting of physical objects to the internet enabling communication from, and to, the object;




6. Digital Reality: virtual digital worlds or systems (virtual reality) or mixed virtual and physical worlds (augmented reality); and

Digital with
Purpose:
Delivering a
SMARTer 2030



**Ympäristövaikutusten
linkitys muihin
kestävyyssdimensioihin**

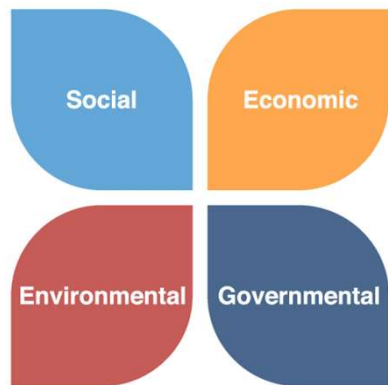
A small green plant with several leaves is growing out of a laptop keyboard. The background is a blurred image of the laptop's keys and the plant's stem.

Brundtlandin raportin dimensiot

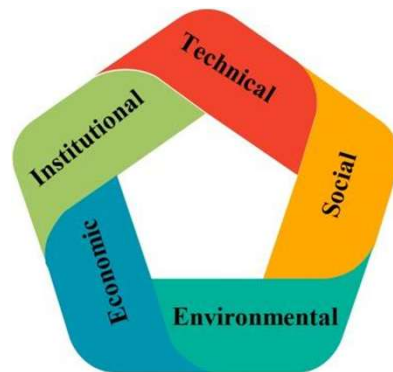
- **Ekologinen** (ecological) - Hyvinvoinnin lisääminen ilman luonnon monimuotoisuuden tai luonnonvarojen vähenemistä
- **Taloudellinen** (economic) - Tasapainoinen taloudellinen kasvu, tavoitteena tarjota tuotteet ja palvelut siten etteivät talouden perusteena olevat ekosysteemipalvelut vaarannu
- **Yhteiskunnallinen** (social) -Yhteiskunnan tasa-arvoinen kehittäminen



Kestävyyden dimensioita



Shen, C. & Pena-Mora, F.:
Blockchain for Cities – A Systematic Literature Review (2018)



Ebrahimi, M. & Rahmani, D.: A five-dimensional approach to sustainability for prioritizing energy production systems using a revised GRA method: A case study (2019)



Biedermann, A.M.; Muñoz López, N.; Santolaya Sáenz, J.L.; Asión-Suñer, L.; Galán Pérez, F.J. Methodological Framework for Integrating Cultural Impact in Sustainability Assessments of Cultural Events (2024)



Karlskrona Manifeston dimensiot

- **Yksilöllinen kestävyys** tarkoittaa inhimillisen pääoman ylläpitämistä (esim. terveys, koulutus, taidot, tiedot, johtajuus ja palvelujen saatavuus).
- **Sosiaalinen kestävyys** tähtää yhteiskunnallisten yhteisöjen solidaarisuuden ja palveluiden säilyttämiseen.
- **Taloudellinen kestävyys** tähtää pääoman ja lisäarvon säilyttämiseen.
- **Ympäristön kestävyys** tarkoittaa ihmisten hyvinvoinnin parantamista suojelemalla luonnonvaroja: vettä, maata, ilmaa, mineraaleja ja ekosysteemipalveluita.
- **Tekninen kestävyys** tarkoittaa tiedon, järjestelmien ja infrastruktuurin pitkäikäisyyttä ja niiden riittävää kehitystä ympäristön muuttuvien olosuhteiden mukaan.

<https://sustainabilitydesign.org/karlskrona-manifesto/>



SusAF

- Sustainability Awareness Framework (SusAF) on kysymyspohjainen työkalu ensisijaisesti ohjelmistotuotteiden ja -palveluiden kestävään suunnitteluun.
- Workbook ohjaa työskentelyä eri vaiheiden kautta.



<https://www.suso.academy/en/sustainability-awareness-framework-susaf/>



SusAF

Dimensions: Environmental

Material and resources includes everything that is needed to produce, deploy, operate, and cease a product or service.

- How are materials consumed to produce the product or service?
- What about to operate the product or service? E.g., requires hardware.
- How can it change the way people consume material? E.g., encourage to buy more?

Waste & pollution means effects the product or service might have on soil, atmospheric, and water pollution.

- How can producing parts or supplies generate waste or emissions?
- How can the use itself produce waste or emissions?
- How can it influence how much waste or emissions are generated?
- How can it promote (or impair) recycling?

Biodiversity includes the effects of a product or service on biodiversity in its operational environment and other affected land.

- How can it impact the plants or animals around it? Or elsewhere?
- How can it change composition of the soil around it? E.g., occupying / cropland?
- What about elsewhere?

Energy means all energy use that results from producing and using a product or service.

- How can the product of service affect the need for production of energy?
- What about the use of energy? E.g. encourages less energy.
- Does the hardware run on renewable energy? Is there a way to incentivise that?

Logistics means the effects of the product or service on moving people and/or goods.

- How can it affect the need (and distance) for moving people or goods?
- How can it affect the means by which people or goods move?

Dimensions: Social

Sense of community means the feeling of belonging to an organization, to an area or to a group of like-minded people.

- How can the product or service affect a person's sense of belonging to these groups?

Trust means having a firm belief in the reliability, truth, or ability of someone or something.

- How can the product or service change the trust between the users and the business that owns the system?

Inclusiveness and diversity refers to the inclusion of people who might otherwise be excluded or marginalized.

- How can the product or service impact on how people perceive others?
- What effects can it have on users with different backgrounds, age groups, education levels, or other differences?

Equity means the quality of being fair and impartial.

- How can the system make people to be treated differently from each other? (think data analytics or decision support)

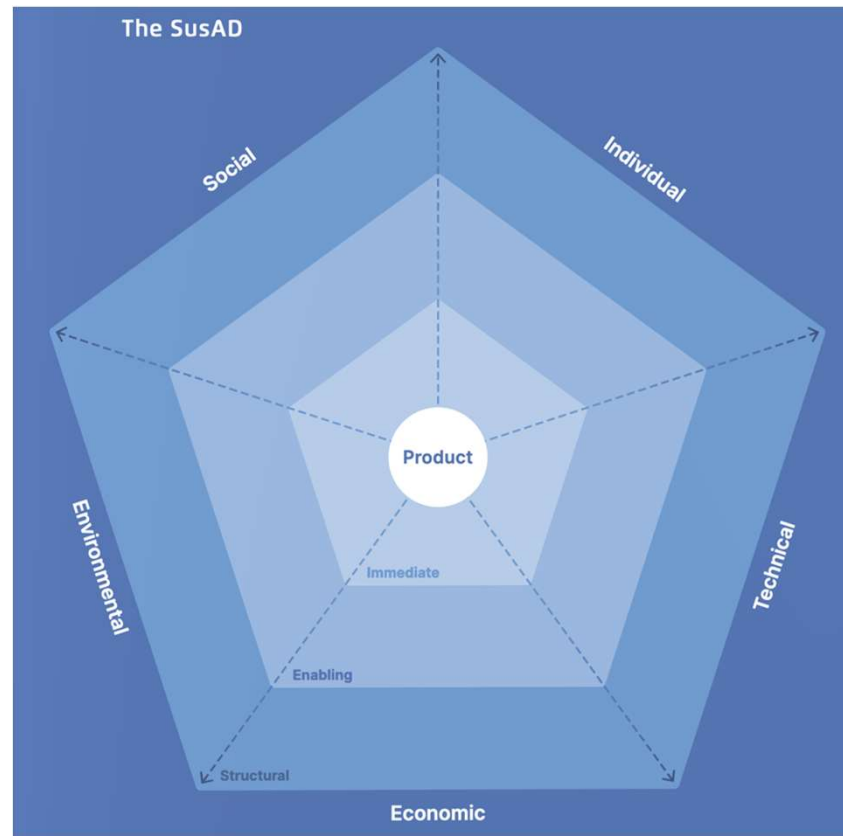
Participation and communication refers to imparting or interchanging thoughts, opinions or information by speech, writing, or signs.

- How can the product or service change the way people:
 - create networks?
 - participate in group work?
 - support, criticize or argue with others?



Sustainability Awareness Diagram

- Tunnistetaan vaikutusten välisiä suhteita
- Ymmärretään linkityksiä, syitä ja seurauksia
- Tuote – Aikaskaalat – Kestävyyden dimensiot

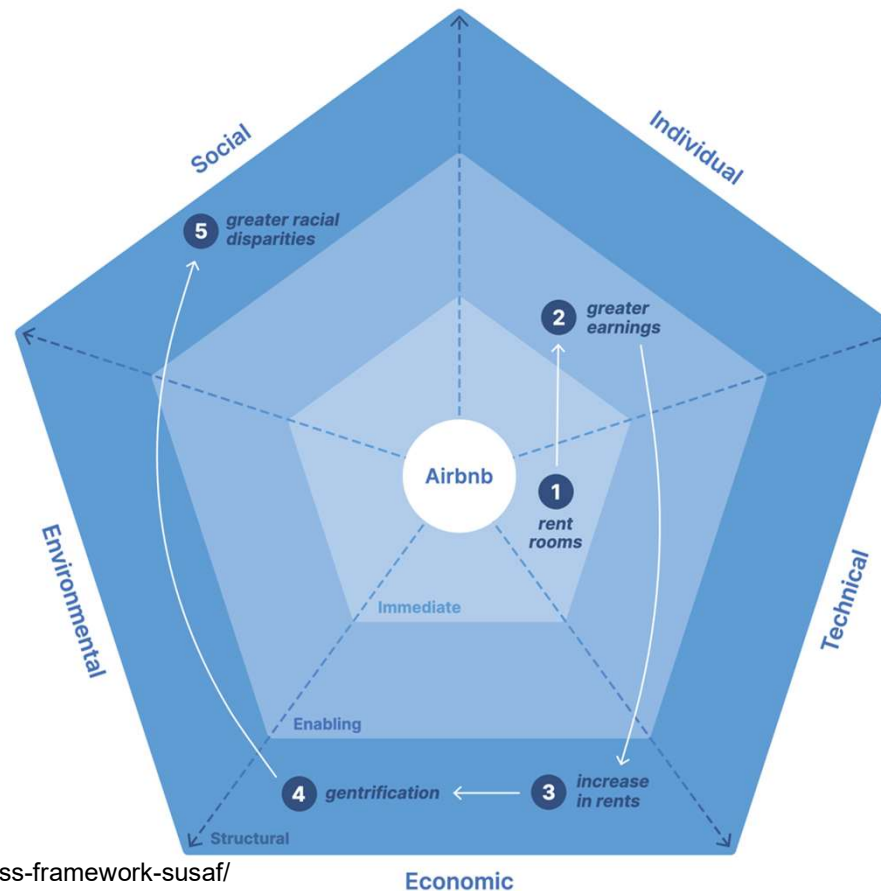


<https://www.suso.academy/en/sustainability-awareness-framework-susaf/>



Esimerkkinä Airbnb ja sen vaikutukset

1. Suora vaikutus (tekninen): huoneen vuokraaminen
2. Välillinen vaikutus (yksilö): tulojen kasvaminen
3. Rakenteellinen vaikutus (talous): vuokratason nousu
4. Rakenteellinen vaikutus (talous): kaupunginosan muutos (keskiluokkainen väestön aiemmin työväenluokkaisella alueella)
5. Rakenteellinen vaikutus (sosiaalinen): suuremmat rotuerot



<https://www.suso.academy/en/sustainability-awareness-framework-susaf/>



2-3-5 muistisääntö ohjelmistojen kestävydestä

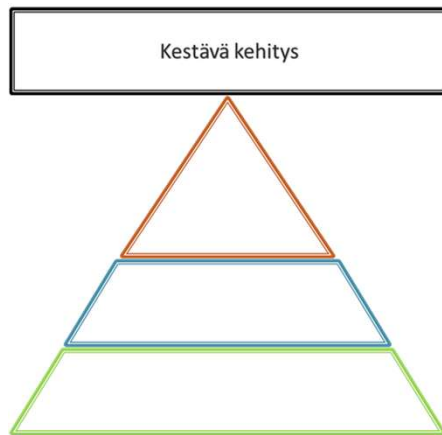
- Kaksi puolta
 - jalanjälki
 - kädenjälki
- Kolme vaikutusten aikaskaalaa
 - suorat vaikutukset
 - epäsuorat vaikutukset
 - systeemiset vaikutukset
- Viisi kestävyden dimensiota
 - ekologinen
 - taloudellinen
 - sosiaalinen
 - yksilöllinen
 - tekninen



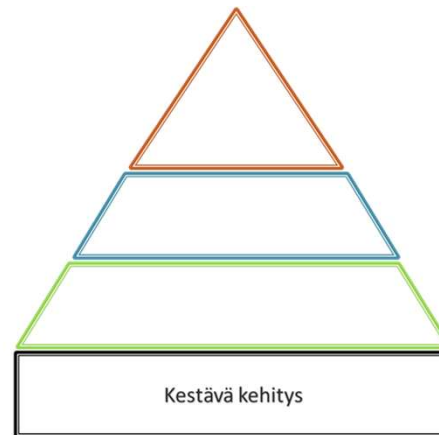
Kestävyyssajattelu

Kestävyyssajattelu

- Kestävä kehitys ei ole tavoitetilä, se on ajattelutapa
- Kestävyys on skaalautuva ominaisuus
- Kestävyys on tasapaino, negatiiviset ja positiiviset vaikutukset
- Kestävyys on systeemistä, vaikutukset suoria, epäsuoria ja rakenteellisia
- Kysymys: Miten voin tehdä tämän asian kestävämmiin?



VAI



Yksilötehtävä



Tehtävä

Jatka työskentelyä valitsemasi ICT-palvelun parissa. **Mieti millaisia kädenjälkivaikutuksia palvelullasi on** aiemmin pohdittujen jalanjälkivaikutusten lisäksi. **Millainen on jalanjälkivaikutusten ja kädenjälkivaikutusten suhde?**

Pohdi lisäksi myös **millä tavoilla ympäristövaikutukset linkittyvät kestävyiden muihin dimensioihin (kokonaiskestävyys)**. **Millä mittareilla eri dimensioiden vaikutuksia voitaisiin mitata?** Palauta tehtäväsi ennen seuraavaa kertaa. Varaudu jälleen esittelemään vastauksesi seuraavalla kerralla hyvin lyhyesti.



Kiitos!

