Responsible digital technologies

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Lab 1 - Consequence trees & limits

Duration	Groups	Evaluation
3 hours	4 students	Lab report

1. Schedule

- Hours 0 - 2:
  - Form a group of 3 - 4 students;
  - Pick a digital service & city (Section 4)
  - Create a consequence tree for this service
- Hours 2 - 2.5:
  - Assess how the digital service would fare against unexpected events
- Hours 2.5 - 3:
  - Cross-evaluation: provide feedback on the consequence tree for another group.

2. Evaluation

This lab counts towards your final grade. You are expected to send a report within the next 2 weeks (see Edunao for the exact dates). This lab's grade is computed as:

- 70% teacher
- 15% cross-evaluation from another group
- 15% quality of your cross-evaluation

Lab report:

- Format: **pdf**
- Length: **max 4 pages** (including consequence tree; keep it condensed).
- **All student names visible**
- Content (see below for more details):
  1. Consequence tree
  2. Associated text justifications, sources, and conclusion
  3. Answer to unexpected events
- Uploaded on **Edunao**

The cross-evaluation is to be uploaded directly on Edunao's form (see Section 6).

3. Context & background

In the first lecture, we have studied the various **direct and indirect effects** of a (digital) solution. As explained, there is more than just the obvious direct effect: induction, substitution, optimization, rebound (direct, indirect, macro-economic), and social change can all occur when deploying a given solution.

Your role today is to act as a **public servant and consultant**. To advise the city council, you must report what the effects of a given digital service in the area would be. To do so, you will build a **consequence tree**. Consequence trees are a method used to **visualize the effects** of a given solution. It can be leveraged to determine the desired scale of its deployment (i.e., partial, complete, none). You can find an example in Figure 1.

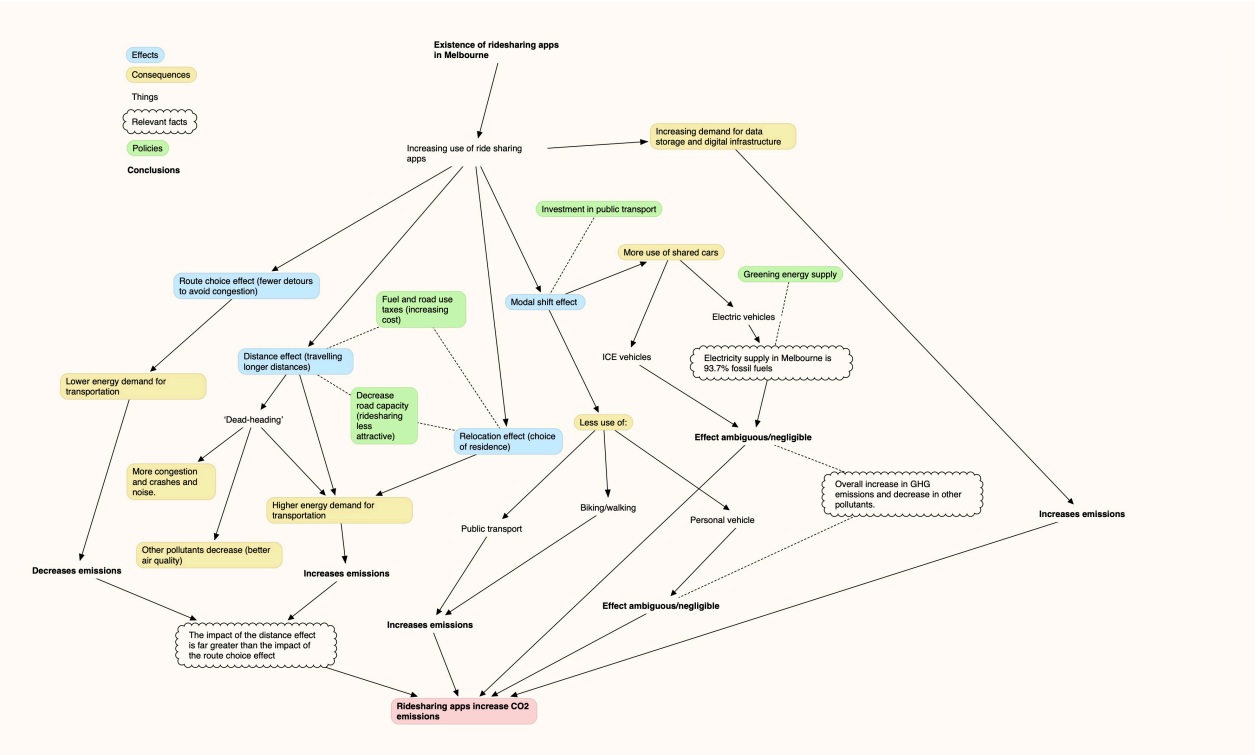

Figure 1: An example consequence tree for deploying VTCs in Melbourne. Be careful: it does not use the ADEME taxonomy. Source: Gauthier Roussilhe. "Cours "Limits to digitalization" – niveau Master" JEESES (2025). Download HD version: https://jeeses.org/article/downloadFullTextAssoc/75/814/1138.

Here is a quick tutorial on how to build a consequence tree, using the direct/indirect effects taxonomy from Lecture 1[1]:

1. **Direct branch:** a single branch for your service's own lifecycle footprint — extraction, fabrication, distribution/installation, usage, end-of-life. Keep it for reference; this is not the focus for today.
2. **Indirect branch:** everything your service causes in the rest of the world. Remember to check Lecture 1's slides to have an overview of possible indirect effects. Each type of effect should be named and/or marked/symbolized.
3. **Sort and select**: for each leaf, note whether it is *actual* (already observable) or *potential* (would follow from continued adoption), and whether it is *immediate* or *mid/long-term*. Then mark 3 to 5 leaves as your *assessment level*: the ones you will actually argue and back with sources. The rest of the tree can stay lighter-touch, but should still be documented.

[1] ADEME. "Évaluation environnementale des effets directs et indirects du numérique pour des cas d'usages" (2026). The general tree-building process is adapted from ITU-T L.1480 (2022), clause 10.2.6 https://www.itu.int/rec/T-REC-L.1480-202507-P/en.

4. **Bonus: attach contextual factors:** add economic, business, structural, or social obstacles and incentives, from the perspective of end users, ICT operators/vendors, investors, policy makers, or society. These explain why an effect is likely (or not) to actually materialize in your assigned city, and are what will make your consequence tree city-specific. Note: if central to your conclusions, these should *also* be backed by sources.
5. **Wrap everything together**: as in Figure 1, point each branch towards a conclusion.

4. Exercise 1: consequence tree (2 hours)

1. Form a group of 3 - 4 students.
2. Pick a digital service and associated city, and communicate to the teacher.

#	Digital service	City	Link to appendix
1	Autonomous vehicles (robotaxis)	Melbourne (Australia)	Section 7.1
2	Smart-city IoT sensor network	Ho Chi Minh City (Vietnam)	Section 7.2
3	Telework / videoconferencing	Munich (Germany)	Section 7.3
4	Generative-AI assistant for citizen services	Bogotá (Colombia)	Section 7.4
5	Cloud gaming / game streaming	Seoul (South Korea)	Section 7.5
6	Precision agriculture	Punjab (India)	Section 7.6
7	Smart electricity metering	Johannesburg (South Africa)	Section 7.7
8	Mobile-based telemedicine	Kigali (Rwanda)	Section 7.8

3. Build a consequence tree, following the approach described in Section 3. It should include immediate direct effects, as well as various indirect effects (following Lecture 1's/ADEME's taxonomy), accounting for future evolutions, i.e., between 2026 - 2050.

> On top of the sources provided by default in the Appendix, you are expected to provide additional ones to back your claims. Sources include but are not limited to:
> - Transition plan / Net zero carbon / low carbon roadmap of cities;
> - Scientific literature (e.g., **via https://scholar.google.com/**);
> - Government-affiliated reports (e.g., ADEME's, IPCC's).
>
> Do not hesitate to look for city-specific sources, as well as parallel studies targeting the same country, or even other countries.

Requirements in the lab report:
- The actual consequence tree;
- Sources;
- Textual description of the main information / findings;
- A short conclusion orienting the city council towards refusing/adapting/adopting the digital solution.

It is entirely possible no conclusive results could be reached due to conflicting sources and lack of time (2 hours is *short*). In that case, a nuanced approach and suggestions for future explorations that could help you decide are required.

To create the consequence tree, you may want to use https://app.diagrams.net/, which provides a free, local-first, export-as-pdf diagram tool.

Tips:
- Link arrows to other elements so you can freely move them around.
- Use colors/shapes and a legend to communicate which effect / timeline is concerned.
- File -> Export As -> PDF

5. Exercise 2: unexpected events (30min)

Following the unexpected events which will be given live in class after the consequence tree is finished:
1. Describe how your consequence tree is impacted.
2. Does it change its conclusion? How so?

Numerous unexpected events are related to the **supply chain**.
Bonus reference: Heydari et al. “A systematic review of resilience in the critical minerals supply chains, needed for the low-carbon energy transition” Renewable and Sustainable Energy Transition (2025) https://www.sciencedirect.com/science/article/pii/S2667095X25000261.

6. Exercise 3: cross-evaluation (30min)

Exchange your consequence tree with another group and evaluate it **on Edunao**, based on the following criteria:
1. Completeness: can you find other direct or indirect effects of the digital solution? Are the ones correctly detailed as direct/indirect effects?
2. Justifications: are quality sources used to justify its claims?
3. Conclusions: do you agree with the conclusion of the consequence tree?

7. Subjects

You may notice that the wealthier cities below face largely discretionary questions, while others correspond to active resource crises. This asymmetry mirrors the actual state of these debates worldwide, and is worth keeping in mind as you write your conclusion.

7.1. Subject 1: Autonomous vehicles (robotaxis), Melbourne (Australia)

- **Goal**: Assess whether Melbourne should refuse, adapt, or fully adopt robotaxi services.
- **Base resources**:
  - Victorian Government (DEECA). “Victoria’s Climate Change Strategy 2026-30” (2025). https://www.climatechange.vic.gov.au/victorias-climate-change-strategy/victorias-climate-change-strategy-2026-30.pdf
  - Onat et al. “Rebound effects undermine carbon footprint reduction potential of autonomous electric vehicles” Nature Communications (2023). https://doi.org/10.1038/s41467-023-41992-2

7.2. Subject 2: Smart-city IoT sensor network, Ho Chi Minh City (Vietnam)

- **Goal**: Assess whether Ho Chi Minh City should refuse, adapt, or fully adopt its IoT-enabled “smart transport” sensor network.

- **Base resources**:
  - *Context*: VietnamPlus. “Ho Chi Minh City to integrate IoT into smart transport infrastructure” (12 Aug 2026). https://en.vietnamplus.vn/ho-chi-minh-city-to-integrate-iot-into-smart-transport-infrastructure-post349858.vnp
  - Prime Minister of Vietnam. Decision No. 950/QD-TTg, “Approving the Scheme for Development of Smart Sustainable Cities in Vietnam in the 2018-2025 Period with Orientations by 2030” (2018), naming Ho Chi Minh City as one of the country’s “nuclear” smart cities. https://thuviennhadat.vn/van-ban-phap-luat-viet-nam/decision-950-qd-ttg-2018-approving-scheme-development-of-smart-sustainable-cities-in-vietnam-391028.html
  - Pirson et al. “Assessing the embodied carbon footprint of IoT edge devices with a bottom-up life-cycle approach” Journal of Cleaner Production (2021). https://doi.org/10.1016/j.jclepro.2021.128966

7.3. Subject 3: Telework / videoconferencing, Munich (Germany)

- **Goal**: Assess whether Munich should refuse, adapt, or fully adopt continued growth in telework/videoconferencing.
- **Base resources**:
  - (In German): Landeshauptstadt München (with Öko-Institut, Hamburg Institut, Intraplan). “Maßnahmenplan Klimaneutralität München” (2022). https://stadt.muenchen.de/dam/jcr:dc76020e-b14b-42ca-9eea-4c3ce538b951/Massnahmenplan-Klimaneutralitaet-Muenchen.pdf
  - Hook et al. “A systematic review of the energy and climate impacts of teleworking” Environmental Research Letters (2020). https://iopscience.iop.org/article/10.1088/1748-9326/ab8a84

7.4. Subject 4: Generative-AI assistant for citizen services, Bogotá (Colombia)

- **Goal**: Assess whether Bogotá should refuse, adapt, or fully adopt “Chatico,” its generative-AI virtual assistant for citizen-facing municipal services.
- **Base resources**:
  - (In Spanish): Alcaldía Mayor de Bogotá / Consejería Distrital de TIC. “Chatico, agente virtual de Bogotá, se renueva con IA generativa” (29 Jan 2026). https://bogota.gov.co/mi-ciudad/gestion-publica/chatico-agente-virtual-de-bogota-se-renueva-con-ia-generativa-2026
  - Luccioni et al. “Power Hungry Processing: Watts Driving the Cost of AI Deployment?” ACM FAccT (2024). https://doi.org/10.1145/3630106.3658542
  - Larsen et al. “The impact of chatbots on public service provision: A qualitative interview study with citizens and public service providers” Government Information Quarterly (2024). https://doi.org/10.1016/j.giq.2024.101927

7.5. Subject 5: Cloud gaming / game streaming — Seoul

- **Goal**: Assess whether Seoul should refuse, adapt, or fully adopt further scaling of cloud/game-streaming services.
- **Base resources**:
  - Republic of Korea. “2050 Carbon Neutral Strategy of the Republic of Korea” (2020, UNFCCC LT-LEDS submission). https://unfccc.int/sites/default/files/resource/LTS1_RKorea.pdf
  - Preist et al. “Evaluating Sustainable Interaction Design of Digital Services: The Case of YouTube” CHI (2019). https://doi.org/10.1145/3290605.3300627
  - Mills et al. “Toward Greener Gaming: Estimating National Energy Use and Energy Efficiency Potential” The Computer Games Journal (2019). https://link.springer.com/article/10.1007/s40869-019-00084-2

7.6. Subject 6: Connected/precision agriculture sensors — Punjab (India)

- **Goal**: Assess whether Punjab should refuse, adapt, or fully adopt connected precision-agriculture sensors across its farmland.
- **Base resources**:
  - Punjab State Council for Science & Technology. "Punjab State Action Plan on Climate Change 2.0 (2021-2030)" (2023). https://pscst.punjab.gov.in/en/PbSAPCC-2.0
  - Taneja et al. "Assessing the economic impact of a low-cost water-saving irrigation technology in Indian Punjab: the tensiometer" Water International 43(2), 178-195 (2018). https://doi.org/10.1080/02508060.2017.1416443
  - Ruder et al. "Reviewing the evidence on precision agriculture and environmental sustainability" npj Sustainable Agriculture (2026). https://doi.org/10.1038/s44264-026-00128-x

7.7. Subject 7: Smart electricity metering — Johannesburg (South Africa)

- **Goal**: Assess whether Johannesburg should refuse, adapt, or fully adopt smart electricity metering and grid digitalization.
- **Base resources**:
  - Presidency of the Republic of South Africa / Presidential Climate Commission. "South Africa's Just Energy Transition Investment Plan (JET IP) 2023–2027" (2022). https://www.climatecommission.org.za/south-africas-jet-ip
  - Carroll et al. "Reducing household electricity demand through smart metering: The role of improved information about energy saving" Energy Economics (2014). https://doi.org/10.1016/j.eneco.2014.07.007
  - Durillon et al. "Environmental assessment of smart energy management systems at distribution level — A review" Renewable and Sustainable Energy Reviews (2024). https://doi.org/10.1016/j.rser.2024.114739

7.8. Subject 8: Mobile-based telemedicine — Kigali (Rwanda)

- **Goal**: Assess whether Kigali should refuse, adapt, or fully adopt mobile-based telemedicine.
- **Base resources**:
  - Ministry of ICT and Innovation (MINICT), Republic of Rwanda. "ICT Sector Strategic Plan (2018–2024)" (2018). https://minict.gov.rw/index.php?eID=dumpFile&f=1110&t=f&token=3c72357ef5a933870448878fe42162871262fcc6
  - *Context*: Rubuga et al. "Telemedicine implementation and healthcare utilization in Rwanda: interrupted time series of babyl digital health services from 2015 to 2024" BMC Primary Care (2026). https://link.springer.com/article/10.1186/s12875-026-03179-8
  - Berger et al. "Aligning With the Goals of the Planetary Health Concept Regarding Ecological Sustainability and Digital Health: Scoping Review" (2025), Journal of Medical Internet Research. https://www.jmir.org/2025/1/e71795

8. Credits

This lab follows the works of Gauthier Roussilhe. “Cours “Limits to digitalization” – niveau Master” JEESES (2025) https://jeeses.org/article/view/75.