Workshop ISA | 13 December 2024

What methods and tools to integrate the practices and uses in the equation of a sustainable mobility?

PhD Candidate
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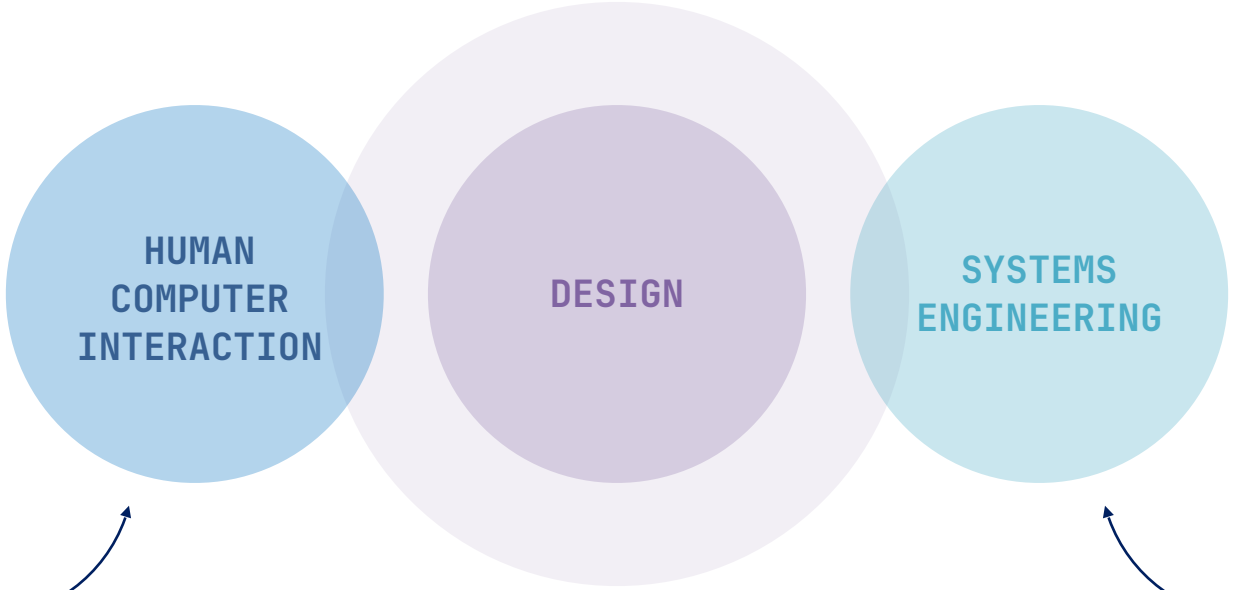
Supervised by
Catherine LETONDAL | ENAC
Rob VINGERHOEDS | ISAE-SUPAERO

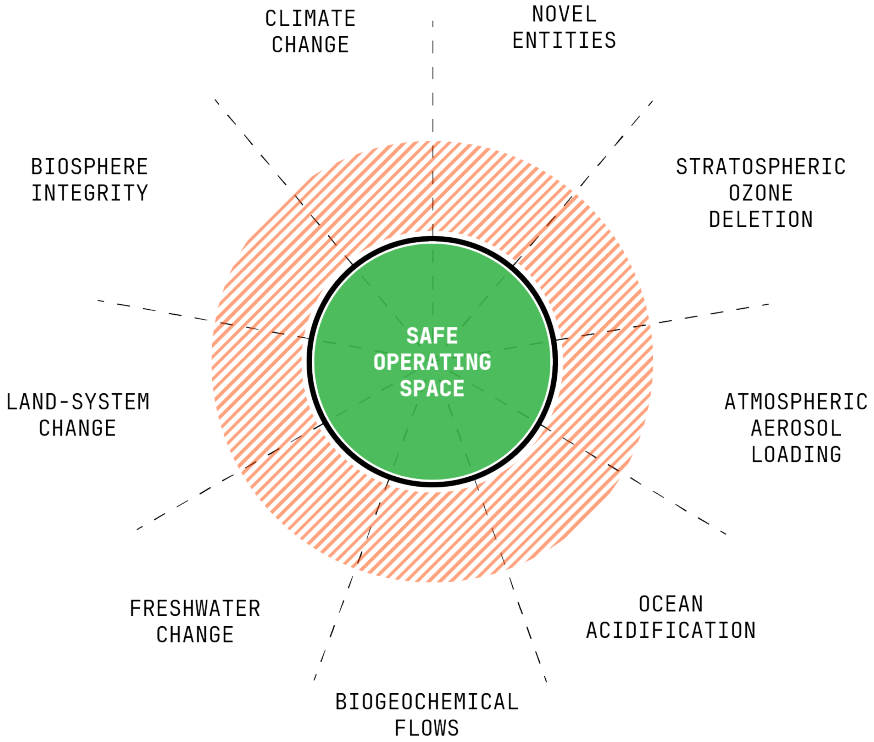
PhD funded by
Fédération de recherche ONERA - ENAC - ISAE SUPAERO

Multidisciplinary thesis



Context & motivation

The planetary situation is alarming



The planetary boundaries framework.
Inspired from: Azote for Stockholm Resilience Centre, Stockholm University. Based on Richardson et al. 2023.

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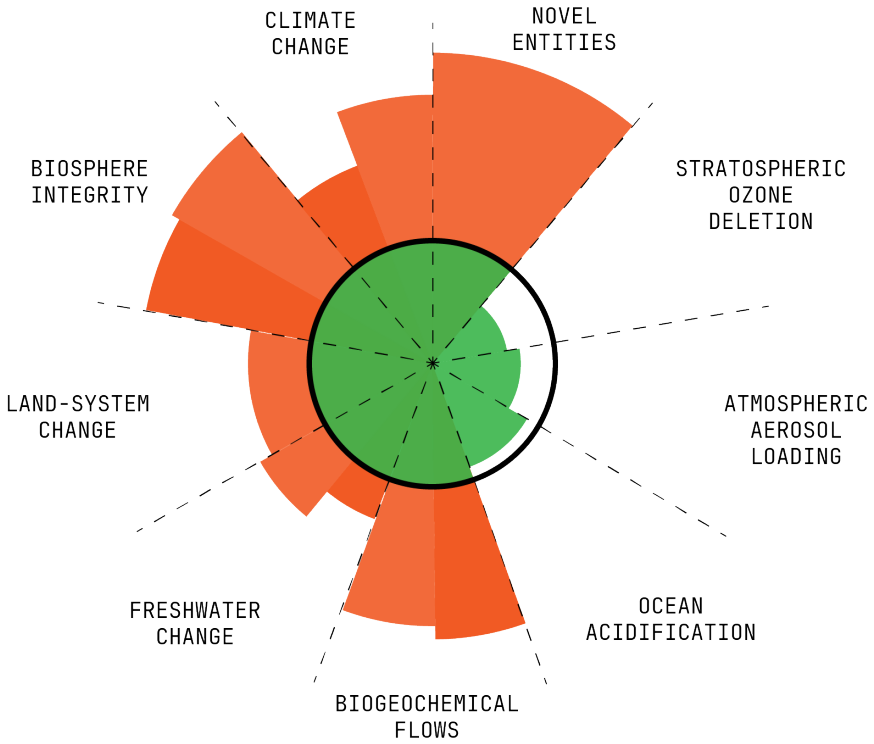

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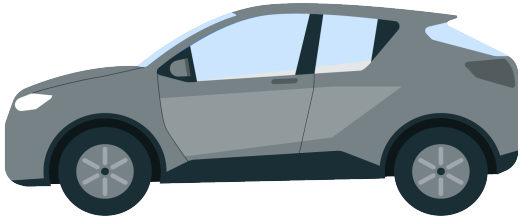
techno-solutionist approaches

used so far do not work



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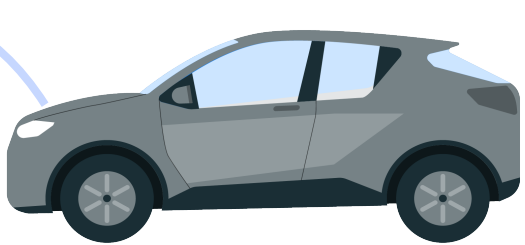

optimising car engines

⬇

increasing overall fuel consumption

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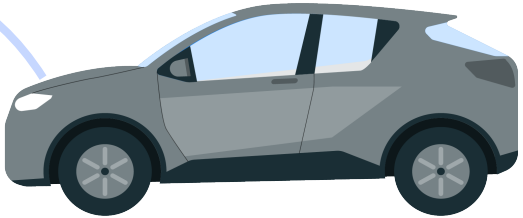

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batteries production

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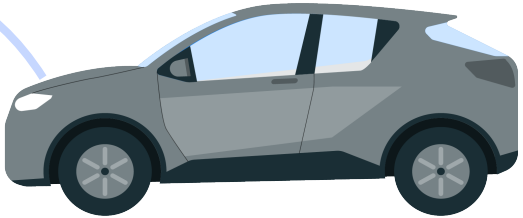

optimising car engines ⬇ increasing overall fuel consumption

batteries production ⬇ socio-environmental impacts due to mining

Faced with this urgent and complex situation, what can digital designers do?

Sustainable HCI*, ICT* and SE*

*HCI: Human-Computer Interaction *ICT: Information and Communication Technology *SE: Systems Engineering

Sustainable HCI*, ICT* and SE*

> *'sustainability and unsustainability are conditions of a "**system as a whole**"'*
>
> [Knowles et al., 2018]

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Sustainable HCI*, ICT* and SE*

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[Knowles et al., 2018]

- imagining new ways of living
- interactions between sectors
- different time scales
- all socio-environmental impacts

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[Raghavan & Pargman, 2017] quoted in [Bremer et al., 2022]

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Could designers take a practical approach to such a huge problem without being reductive?

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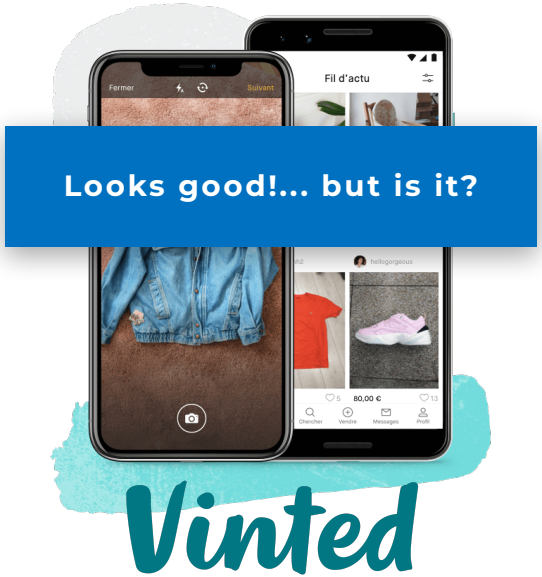
Vinted | Second hand resale platform

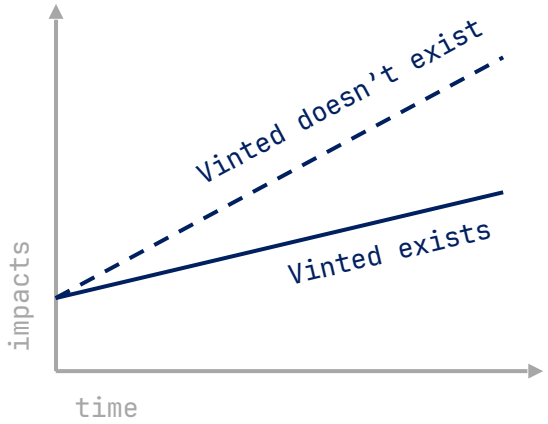


Vaayu study on Vinted avoided emissions

Avoided emissions = **453 ktCO2eq** (**1.8kgCO2eq** per purchase)

Vaayu, “Vinted Climate Change Impact Report,” Vaayu, 2021

What is behind this calculation?



Consequential approach

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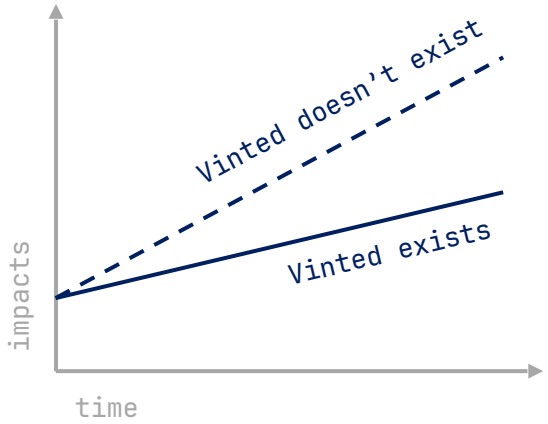

Consequential approach

BUYERS

If Vinted didn't exist, you would have bought this item...

(a) brand new
(b) second hand (elsewhere)
(c) no, I was just browsing...

SELLERS

If Vinted didn't exist, you would have...

(a) sold this item elsewhere
(b) given this item to charities
(c) thrown it...

Consequential LCA based on a 350,000 Vinted users survey
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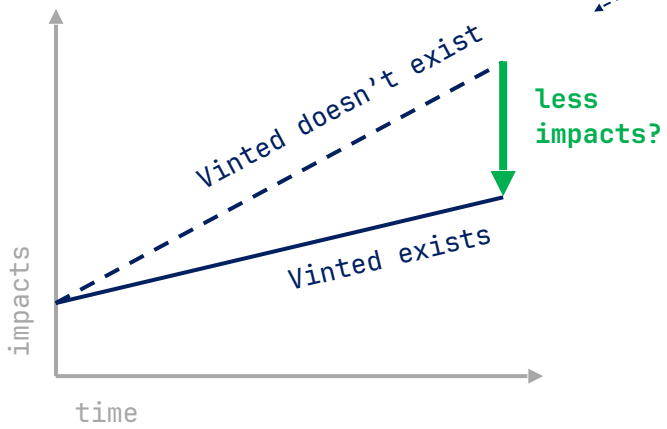

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Some direct and indirect effects of Vinted

DIRECT IMPACTS

Carbon emissions and pollutions due to parcel delivery and operations

ENABLEMENTS

Avoided impacts due to people buying second-hand instead of new items

QUANTIFIABLE REBOUND EFFECTS

Additional impacts due to impulse buys while scrolling on the platform

Additional impacts due to sellers buying things with money from sales

UNQUANTIFIABLE REBOUND EFFECTS

Decline in charities' social activities due to a drop in donations

Shift in sellers' behaviours towards "consu-merchant" practices

E. Juge, "La fabrique des conso-marchands: une approche par les dispositifs sociotechniques dans le contexte de la consommation collaborative," Ph.D. dissertation, Univ. of Lille, 2018.
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Partially considered in Vinted study

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Additiona

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Not considered in Vinted study

→ it is complex to intervene in a sociotechnical system & achieve positive socioenvironmental impacts

→ the figure produced by the Vinted report does not help designers to improve the impacts

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Research question

&

Approach

How might designers be empowered with **practical methods and tools** to thoughtfully consider the **indirect and rebound effects** of their interventions throughout the design process?

Environmental decision-making levels

Decision makers	Scale of decision	Type of decision	Example in the context of Vinted practical case
Consumer	Product / service	Purchase / use	Deciding whether to buy/sell or not on the Vinted platform based on the environmental and social impacts of this service.
Designer	Product / service	Product / service design	Identifying product design levers to mitigate direct and indirect effects, comparing scenarios, defining a strategy.
Organizational decision maker	Organization portfolio	Strategy design	Deciding to adapt the business model to reduce environmental and social impacts while maintaining the viability of the company. Investing more in products from the portfolio with the best impact.
Investor / shareholder (public / private)	Investment portfolio	Investment	Deciding whether to invest or not in Vinted to green the investment portfolio.
Political decision maker	Society / market	Policy design (regulations, incentives, etc.)	Introducing regulatory mechanisms for companies or consumers to create conditions that enable a reduction in the environmental and social impacts of the clothing sector (regulations, taxes, information, quotas, tax reductions, etc.).

Ekchajzer, D., Bornes, L., Combaz, J., Letondal, C., & Vingerhoeds, R. (2024, June). Decision-making under environmental complexity: the need for moving from avoided impacts of ICT solutions to systems thinking approaches. In 2024 International Conference on ICT for Sustainability (ICT4S).

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Main research question

How might designers and decision-makers be empowered with **practical methods and tools** to thoughtfully consider the **indirect and rebound effects** of their interventions throughout the design and decision-making process?

Research approach

“Systemic modelling methodology”

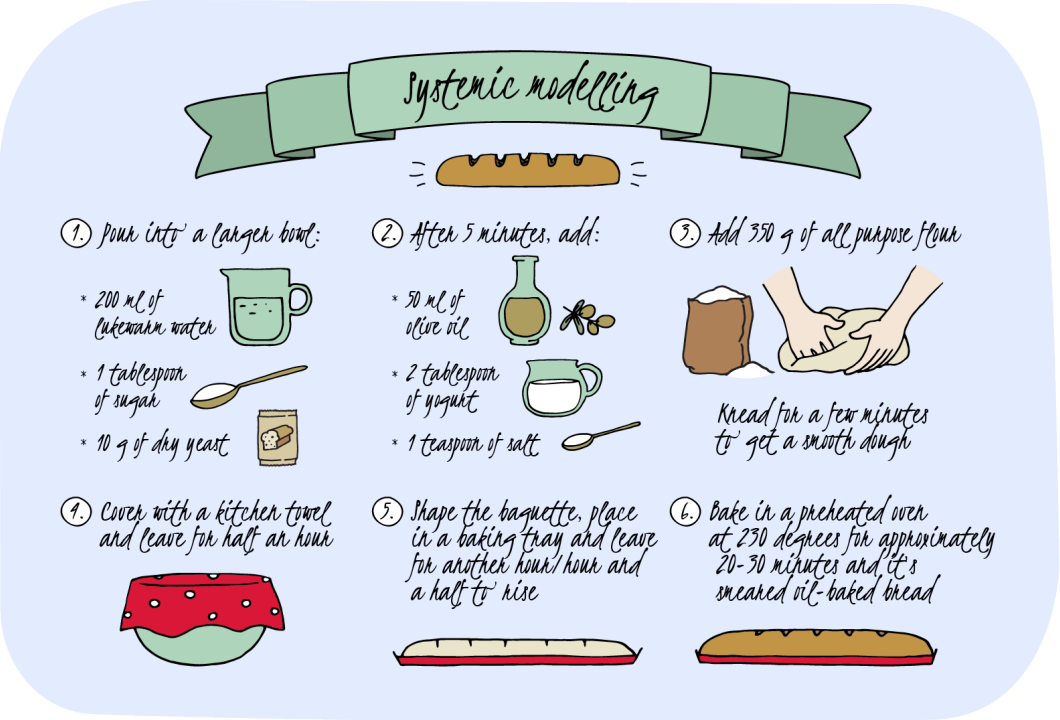
a methodology to help designers tackle rebound effects

How might designers and decision-makers be empowered with **practical methods and tools** to thoughtfully consider the **indirect and rebound effects** of their interventions throughout the design and decision-making process?

Exploratory approach

constructivist-interpretive, based on *action-research*, *research through design*, and *case study* methodology

Designing a methodology… like a recipe

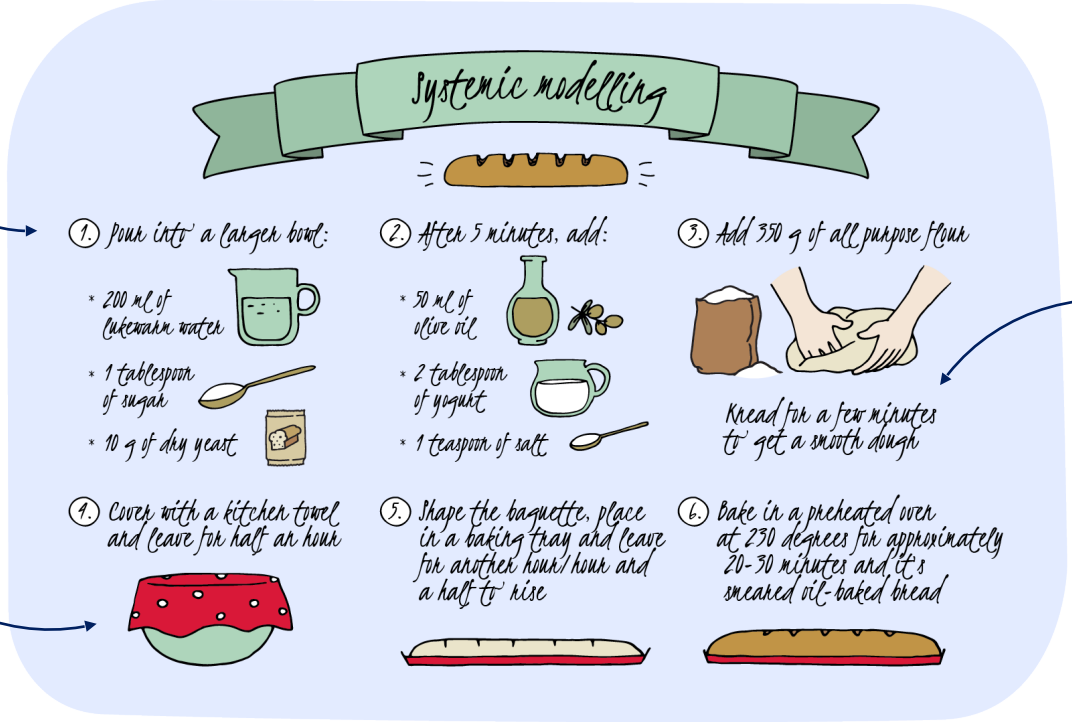


Designing a methodology… like a recipe

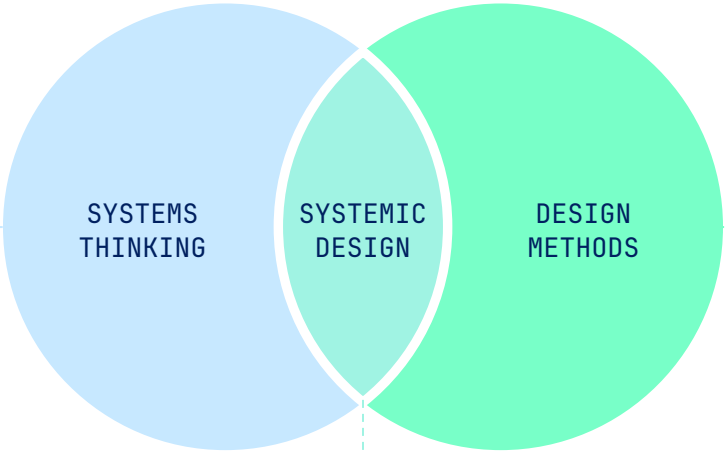
steps

tools

good practices



Systemic design



Systems thinking
interdisciplinary
research field and world-view
opposed to reductionism
importance of interactions within a system, non-linear behaviours, and emergence phenomena.

Design methods
non-linear, iterative process
understand users, challenge assumptions, redefine problems and create innovative solutions that are prototyped and tested
tackling problems that are ill-defined.

Systemic design
emerging interdisciplinary field of research
to address complex, multiscale problems
at the social and sociotechnical level
with practical methods and tools
Relating Systems Thinking and Design (RSD) conference

Systemic modelling methodology

Steps of the systemic modelling methodology

- inspired from Group Model Building -

build a **team** and define a **scope** → build a **qualitative** overview of the situation → build a **quantitative** dynamic model → **compare scenarios** through simulation

Steps of the systemic modelling methodology

- inspired from Group Model Building -

1

build a **team** and define a **scope**

2

build a **qualitative** overview of the situation

- share a common vision
- including non-quantifiable indirect effects
- identify levers for action

3

build a **quantitative** dynamic model

- understand the magnitude of direct and indirect effects

4

compare scenarios through simulation

- compare the potential impacts of different design strategies

1. Requisite variety

"getting the whole system in the room"

[Jones, 2014]

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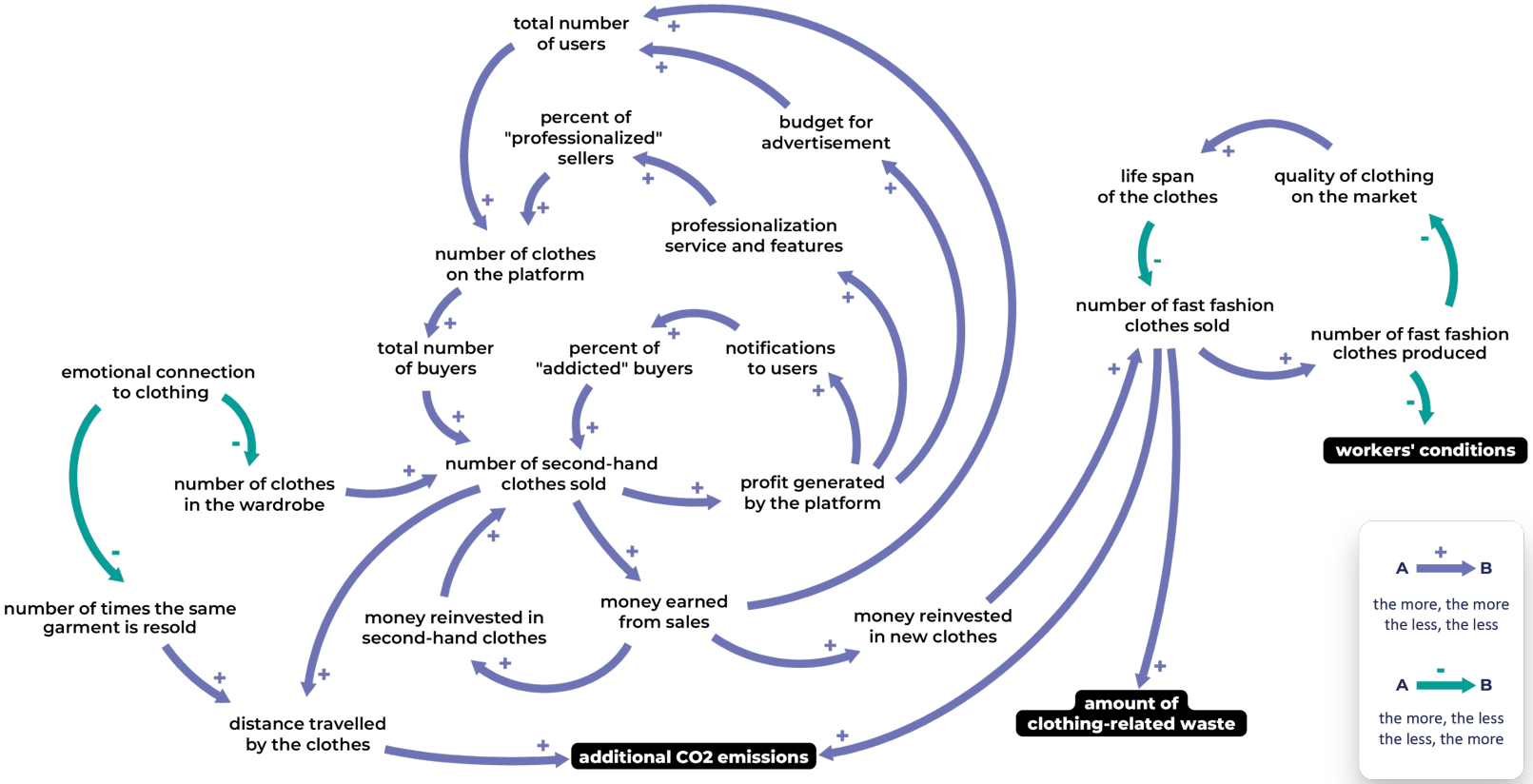
e.g. designers, decision-makers, academics, policy-makers, and citizens

could help to build a more complete picture and reduce the bias/risk of misuse

diverse interests represented

2. Qualitative overview – Causal loop diagram



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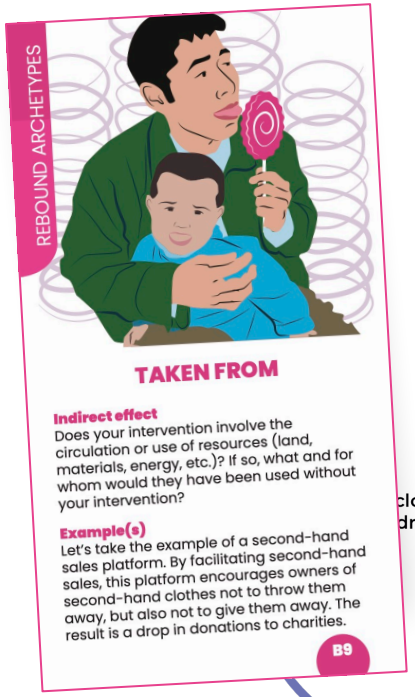

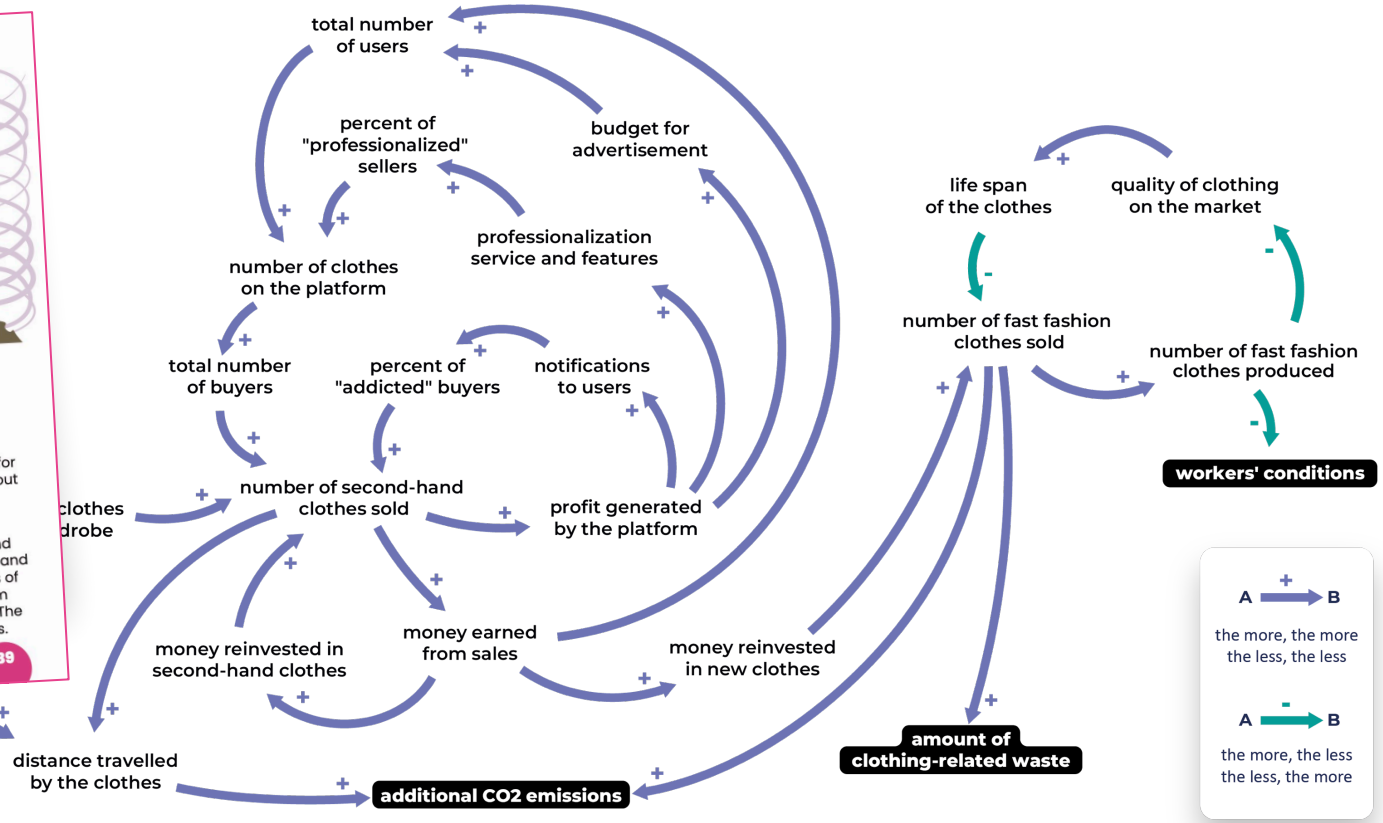

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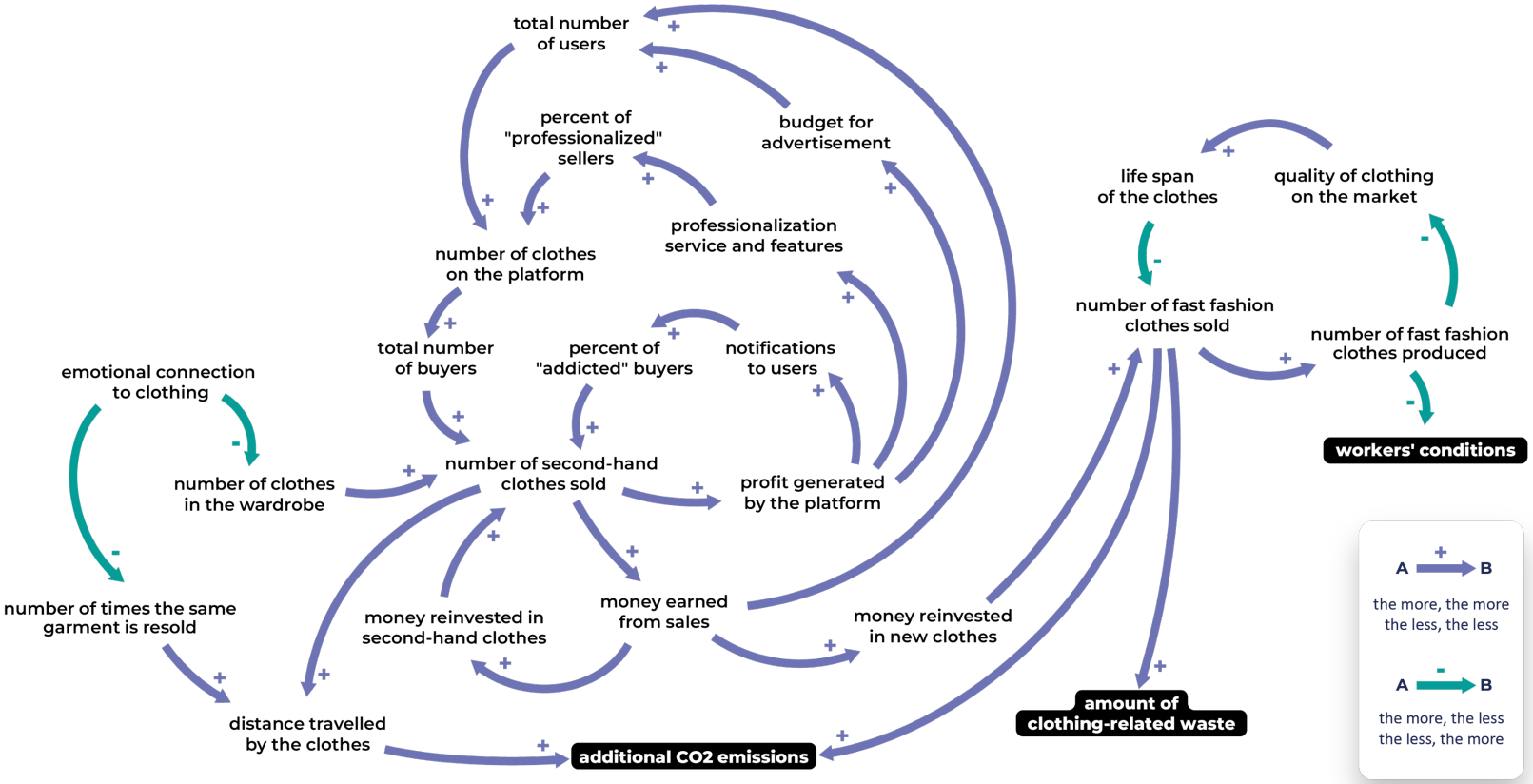

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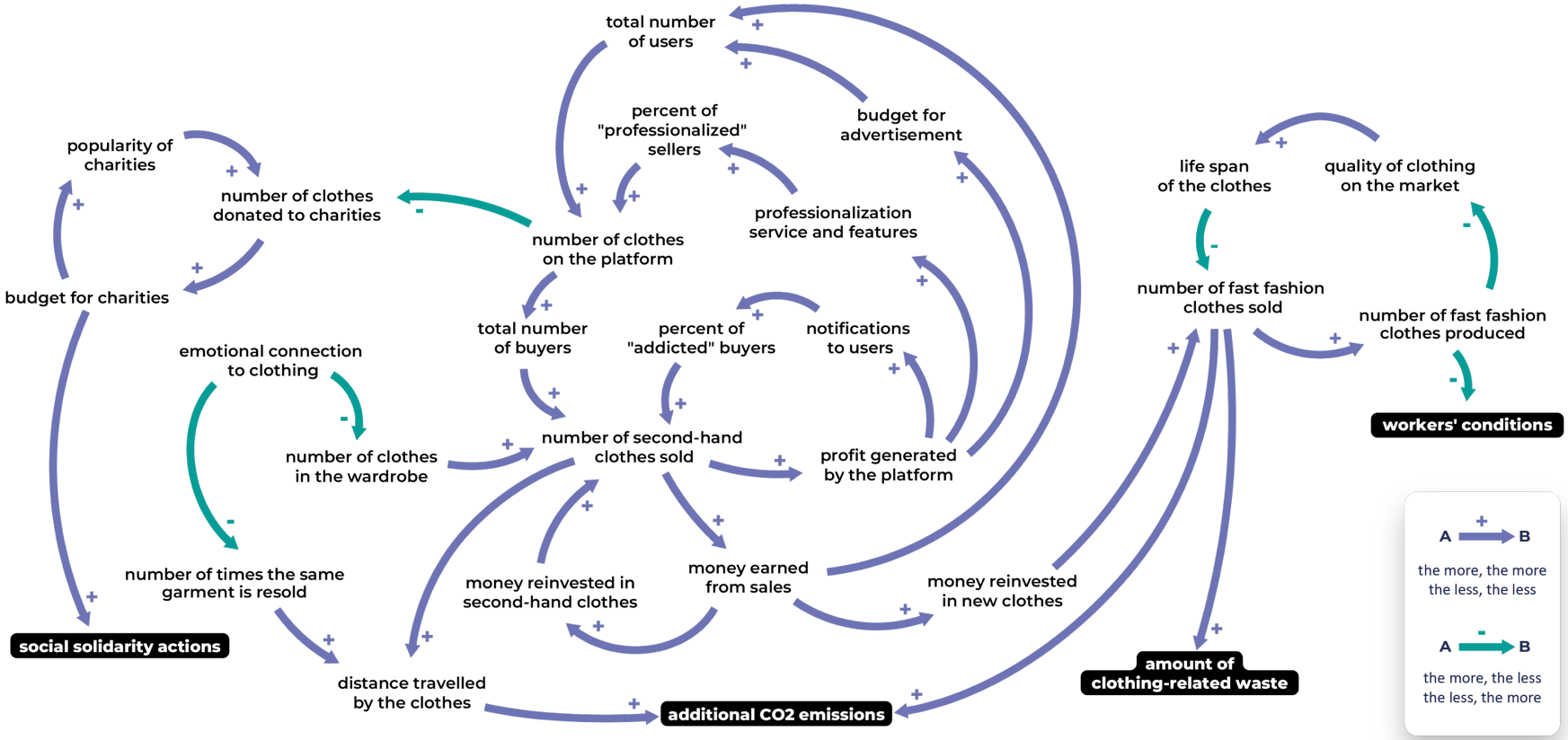

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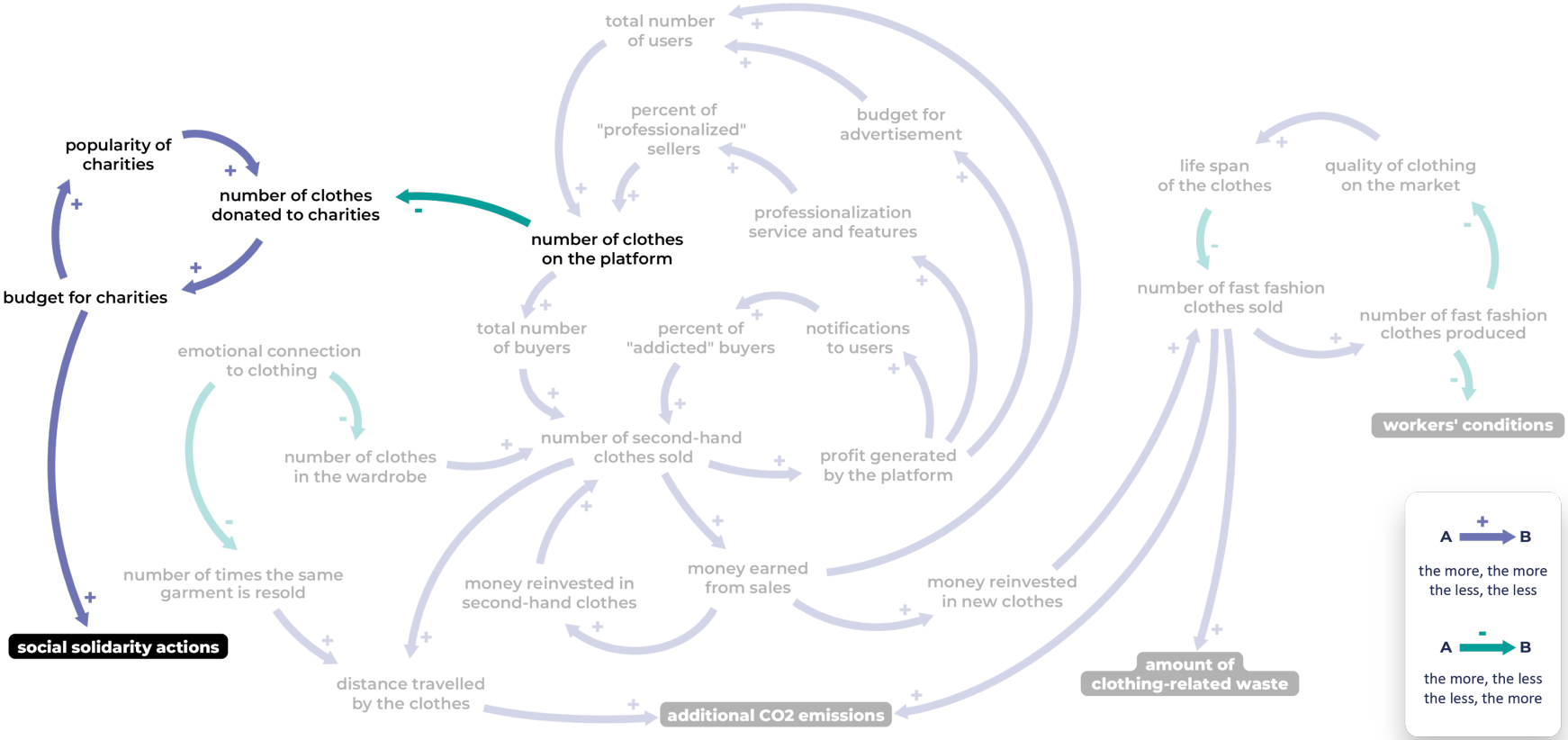

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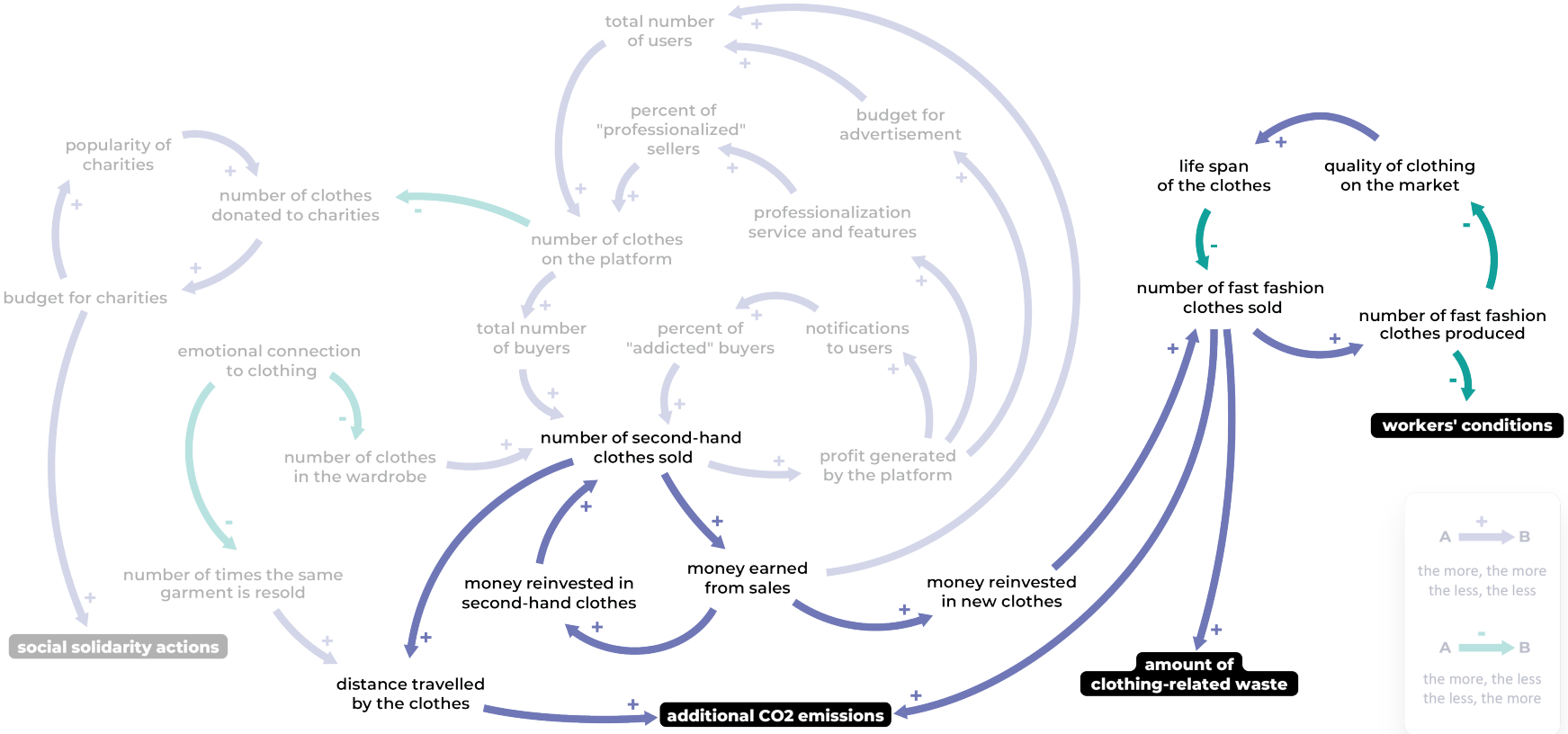

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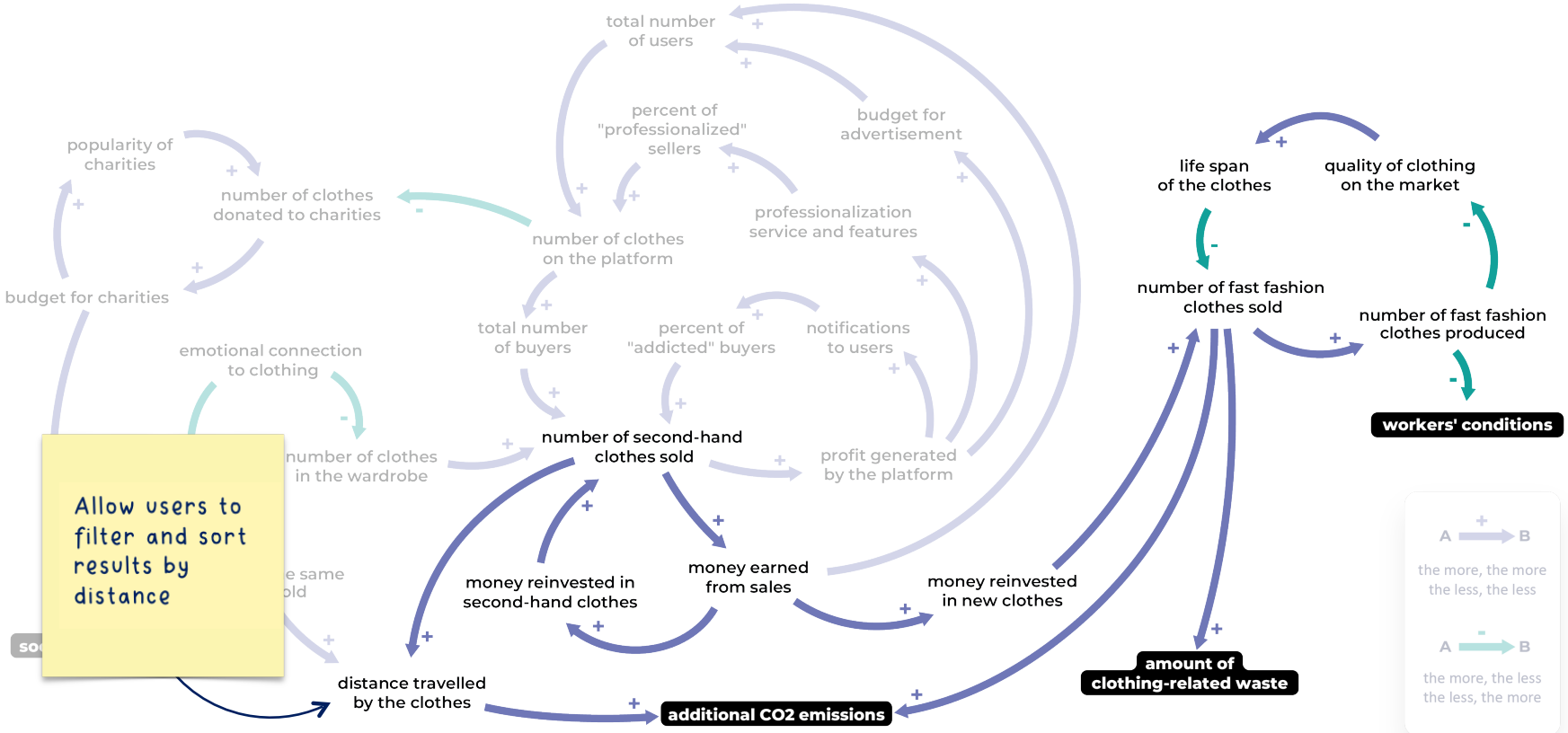

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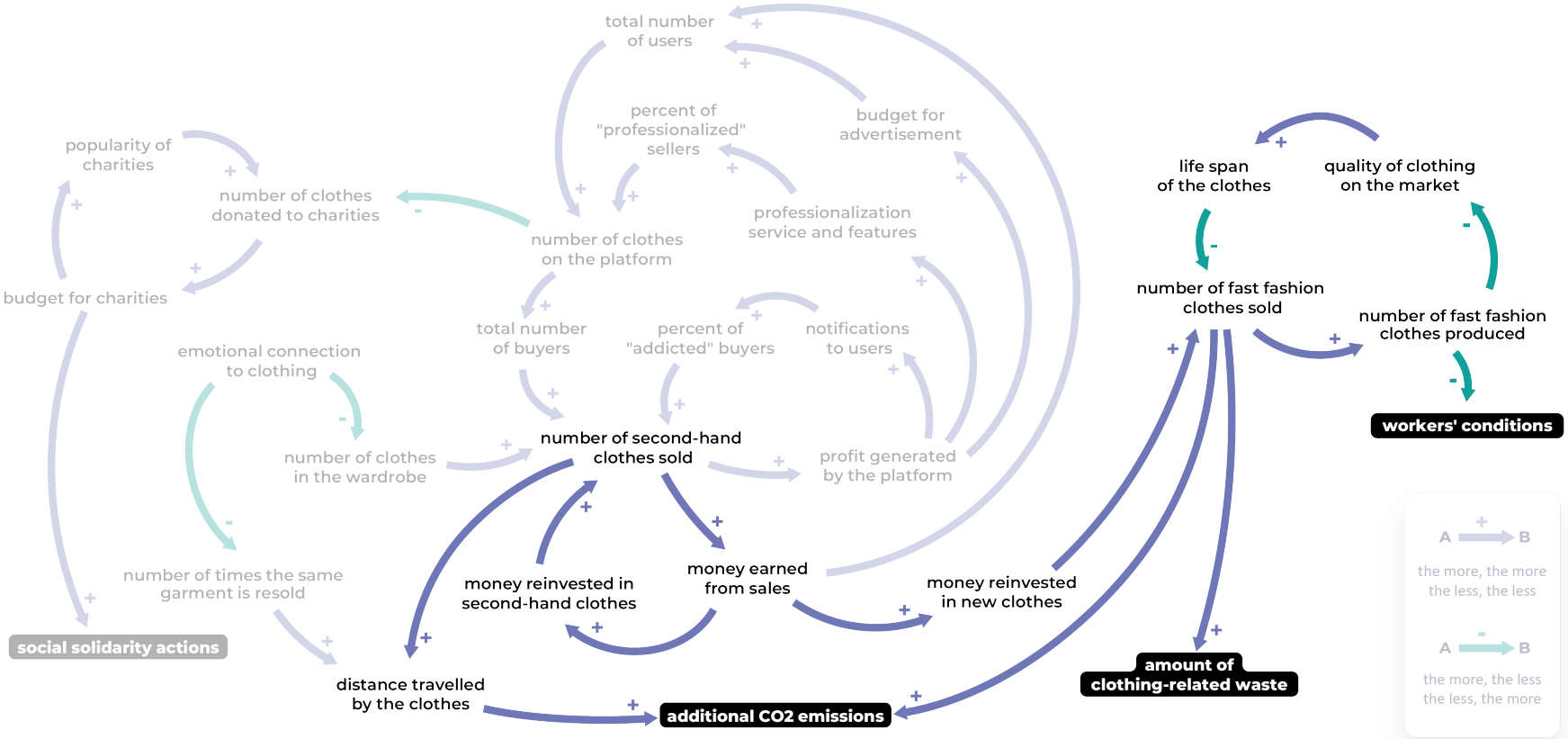

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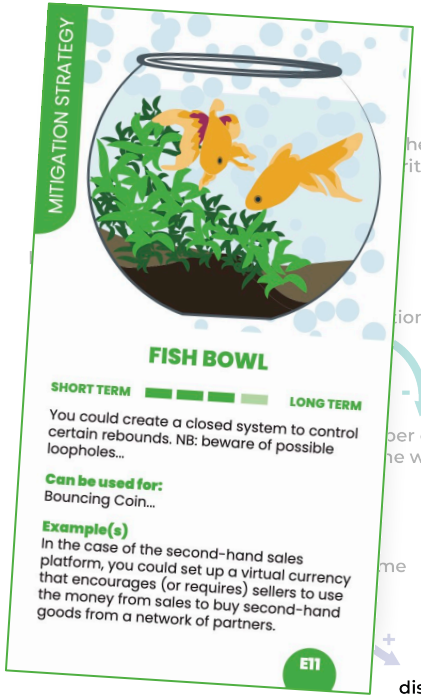

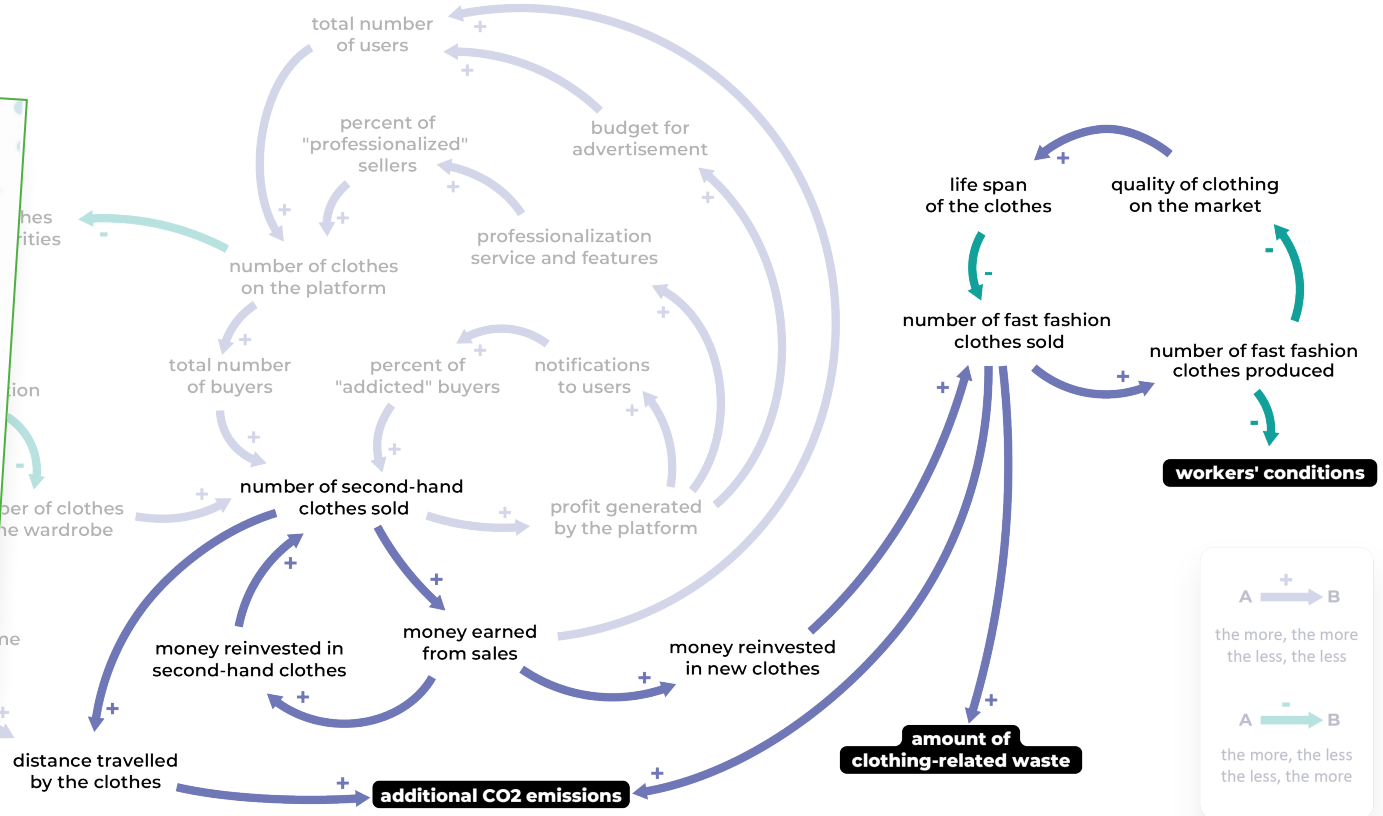

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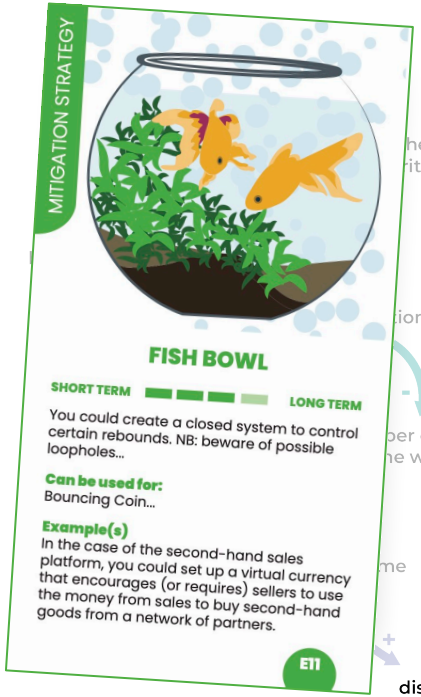

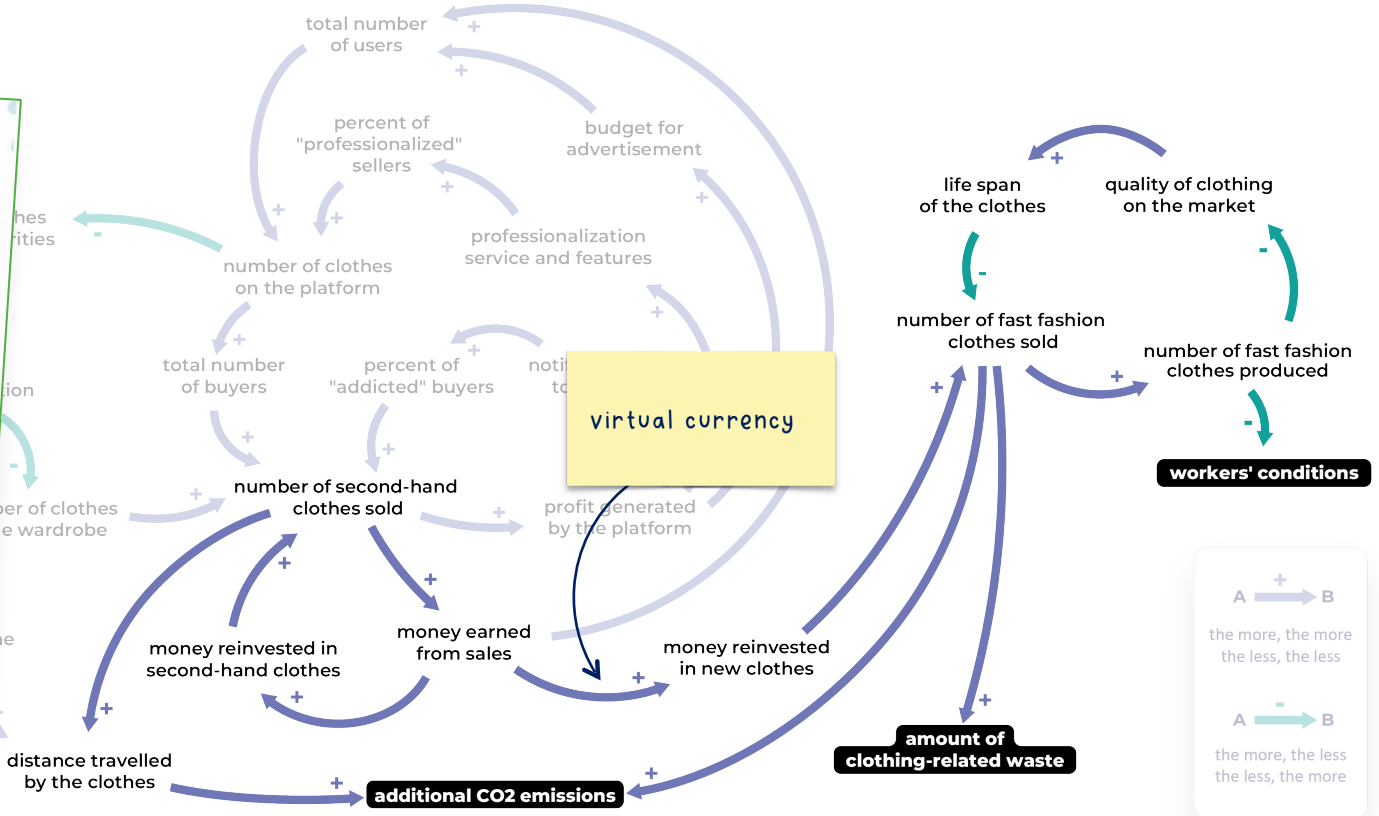

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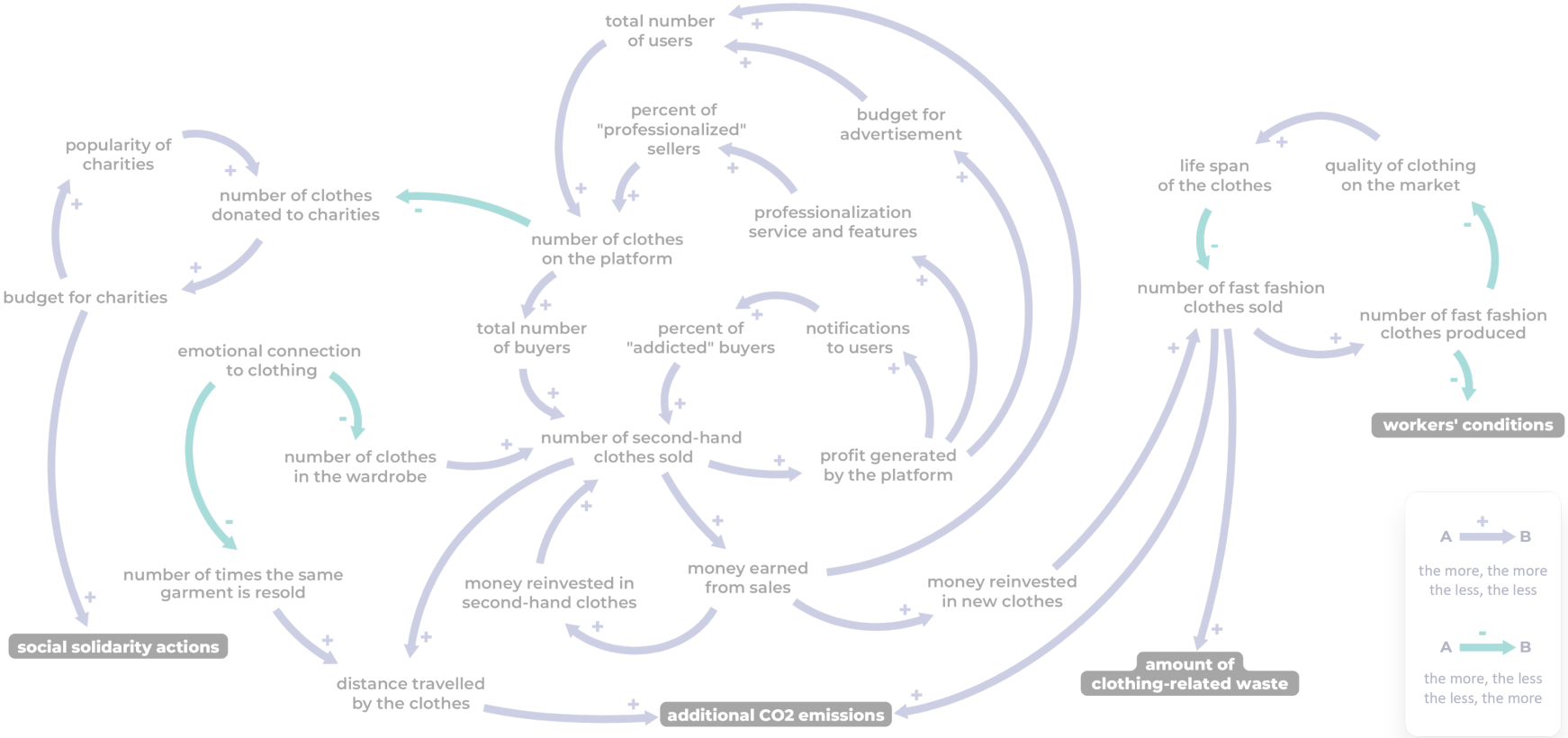

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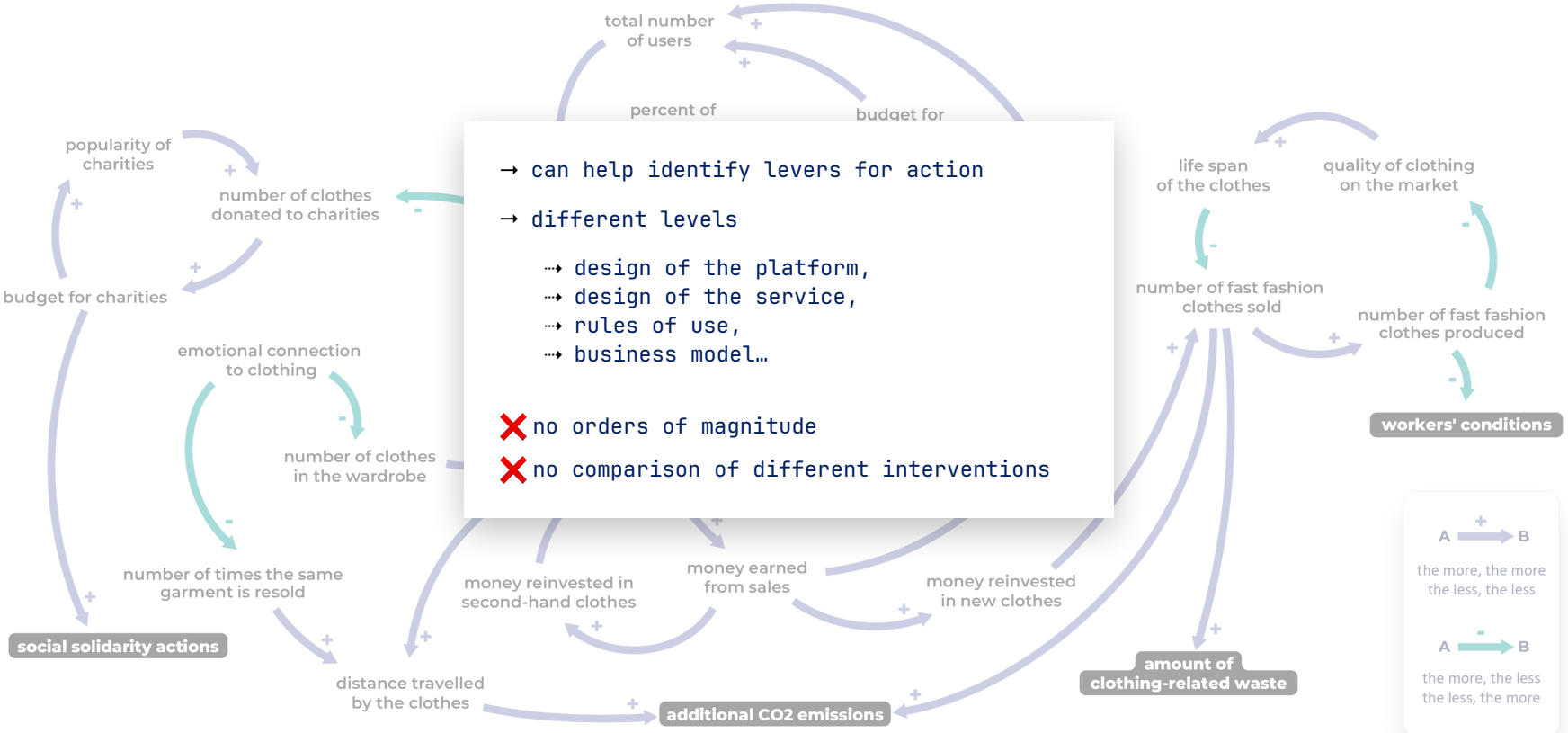
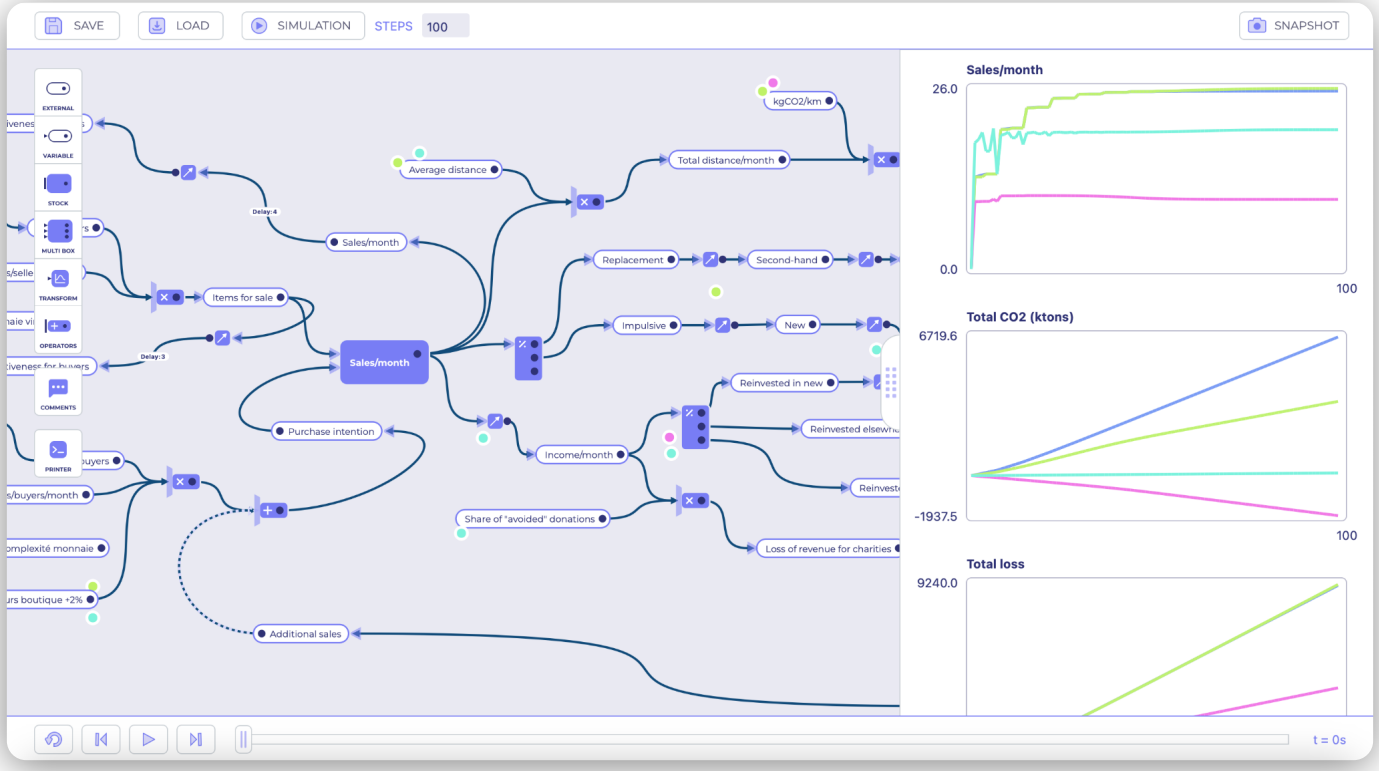


3. Quantitative dynamic model – Magnitude modelling tool



https://lii.enac.fr/projects/magnitude/ (interaction with smala (http://smala.io) & calculations in C++)

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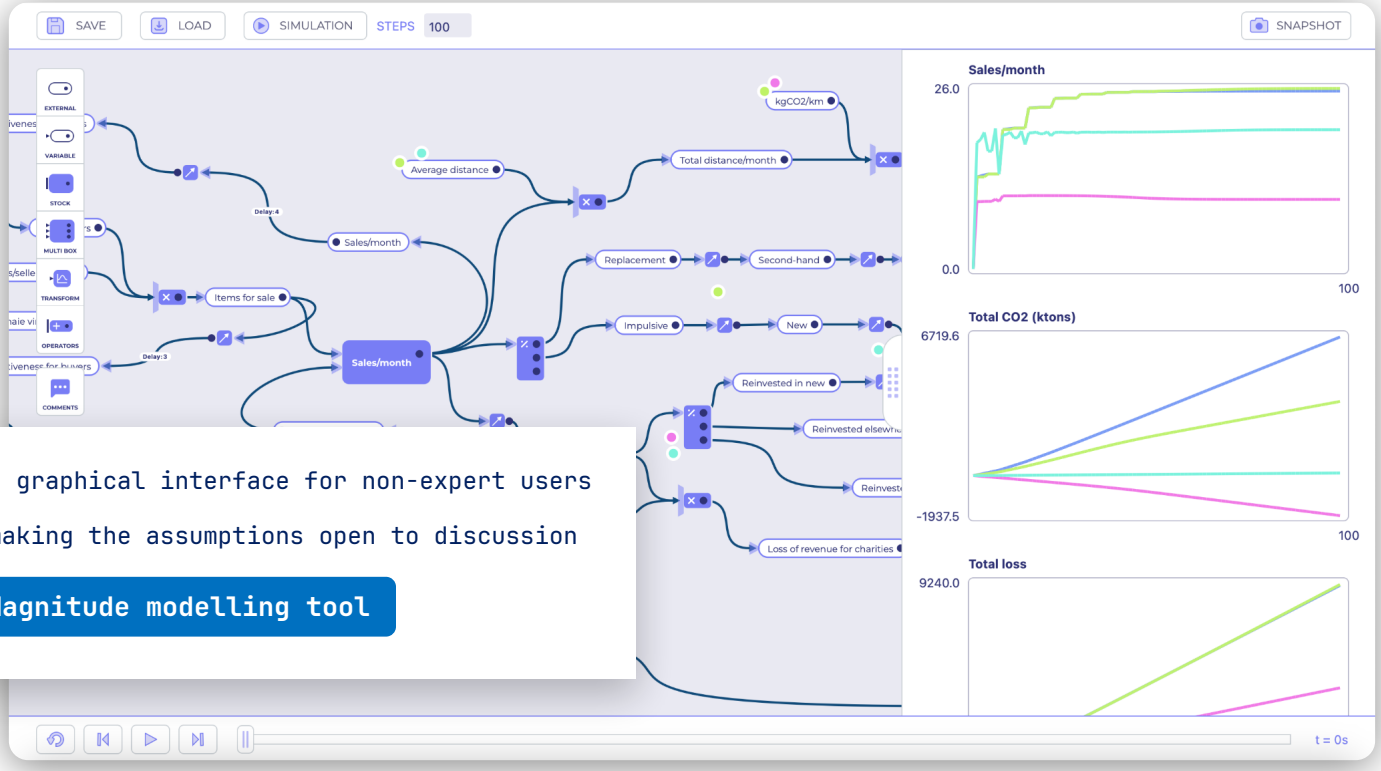

→ a graphical interface for non-expert users

→ making the assumptions open to discussion

Magnitude modelling tool

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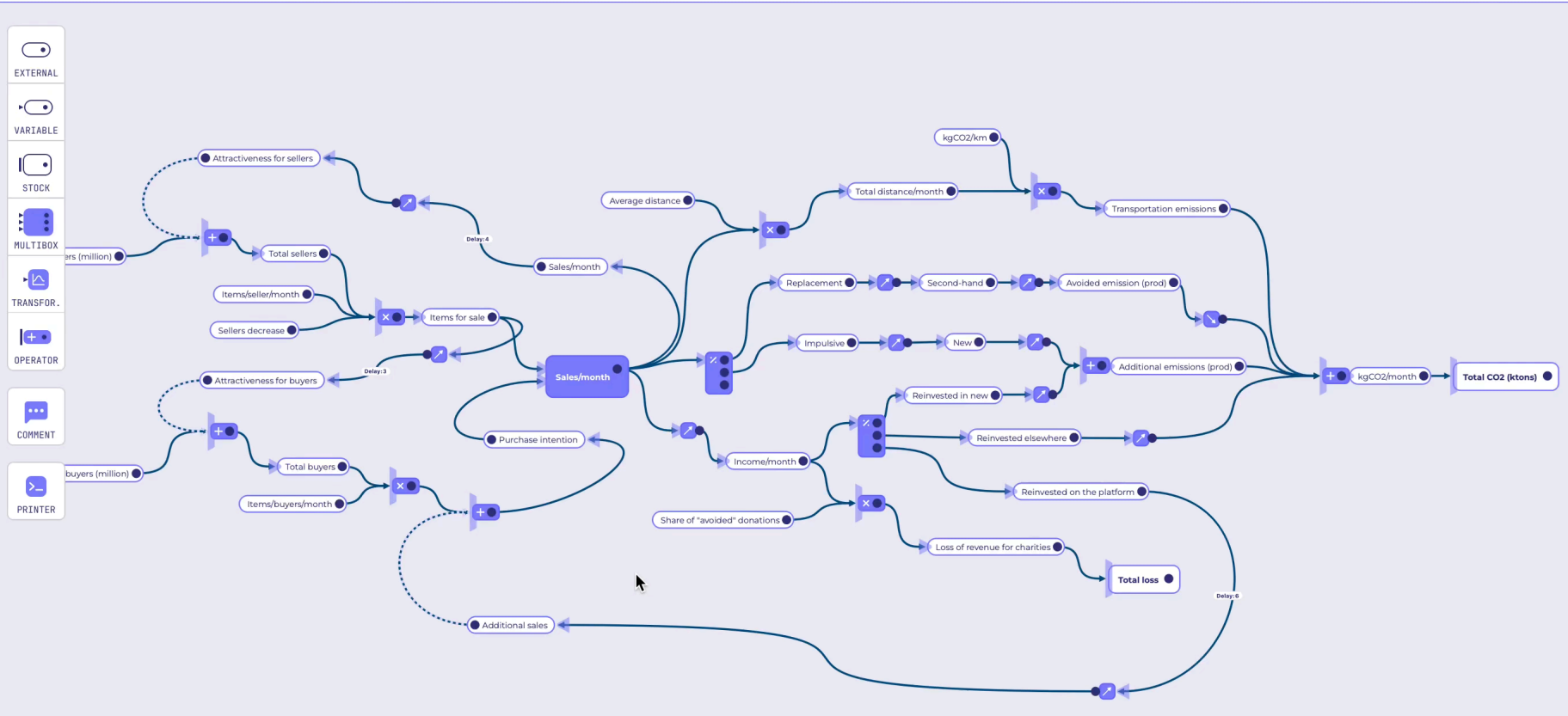
SAVE
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SIMULATION
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TRANSFOR.
OPERATOR
COMMENT
PRINTER
Attractiveness for sellers
Total sellers
Items/seller/month
Sellers decrease
Items for sale
Delay:4
Sales/month
Delay:3
Attractiveness for buyers
Total buyers
Items/buyers/month
Purchase intention
Sales/month
Average distance
Total distance/month
kgCO2/km
Transportation emissions
Replacement
Second-hand
Avoided emission (prod)
Impulsive
New
Additional emissions (prod)
Reinvested in new
Reinvested elsewhere
Reinvested on the platform
Income/month
Share of "avoided" donations
Loss of revenue for charities
Total loss
kgCO2/month
Total CO2 (ktons)
Delay:6
Additional sales
t = 0s

Good practices

identify potential rebound effects

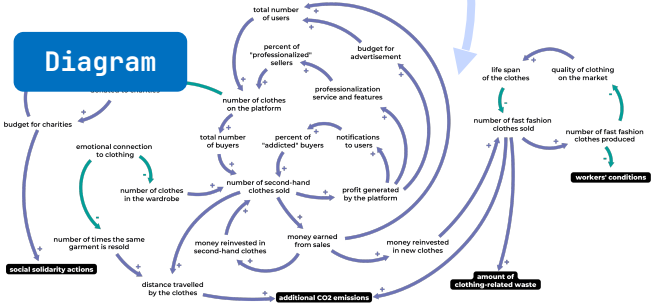
Rebound Archetypes

identify strategies to tackle them

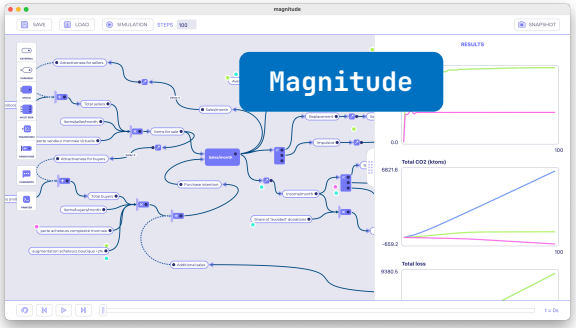
- guide stakeholders throughout the process
- can be used on their own to run quick workshops

build a **team** and define a **scope** → build a **qualitative** overview of the situation → build a **quantitative** dynamic model → **compare scenarios** through simulation

Diagram

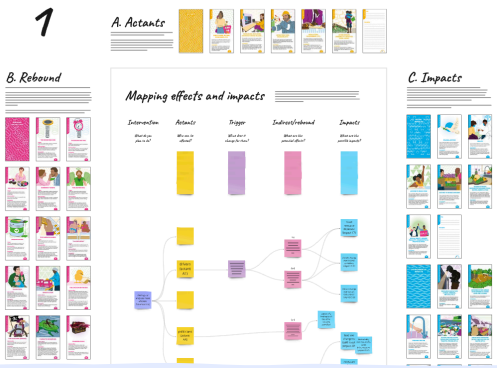


Magnitude



Rebound Archetypes

Creative Commons



In French & English:
> Cards to print
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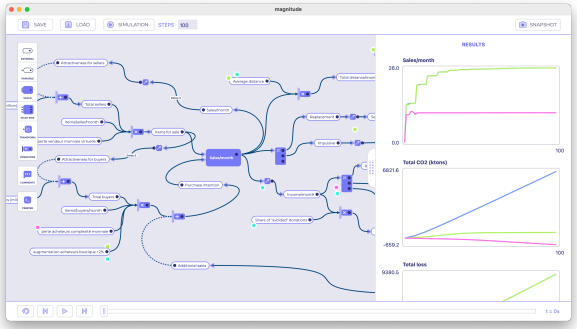
Magnitude

Open/free access

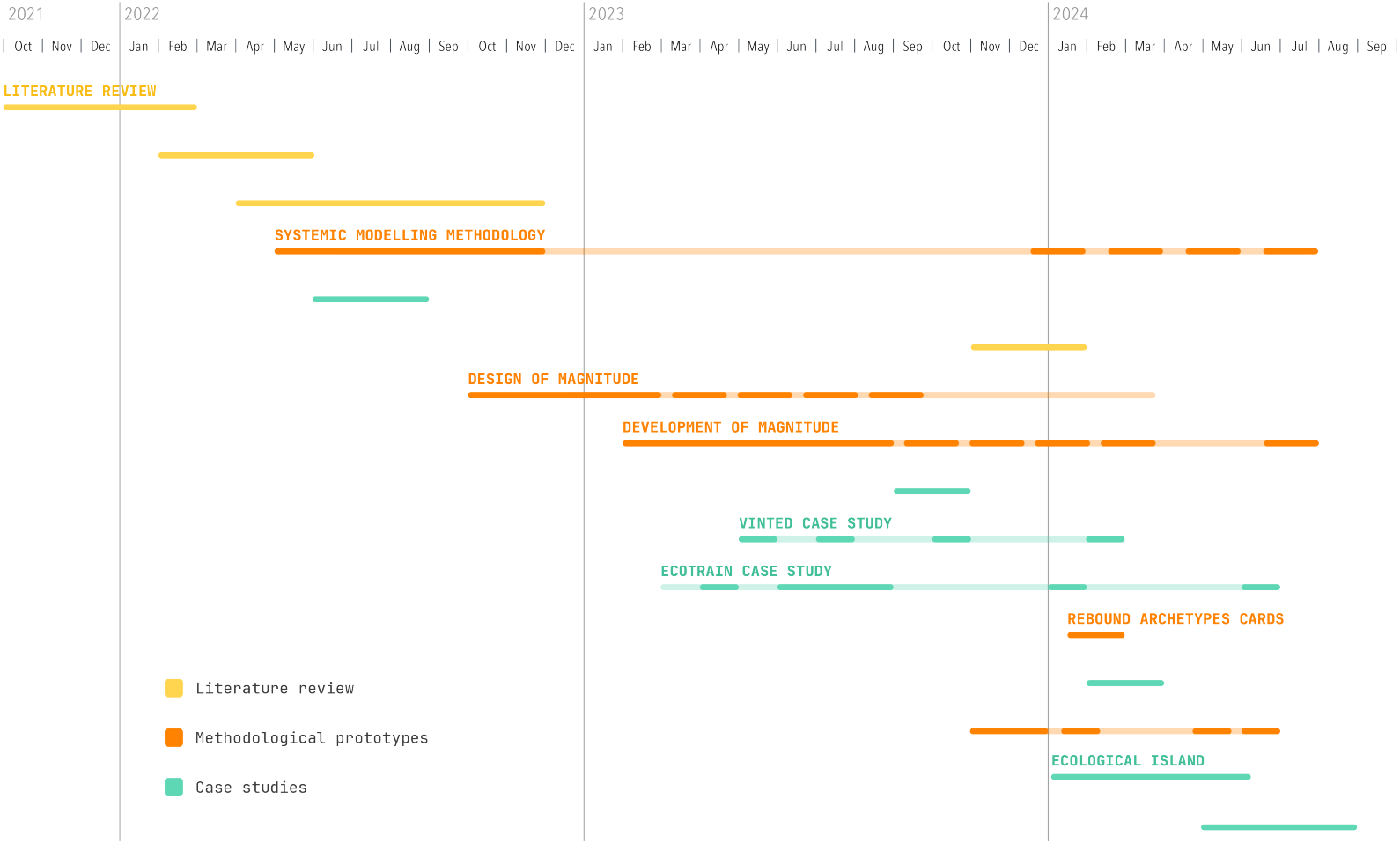


For Windows & Mac:
> Magnitude modelling tool
> guidelines (English)
> examples of models…

Case studies

&

some results


2021
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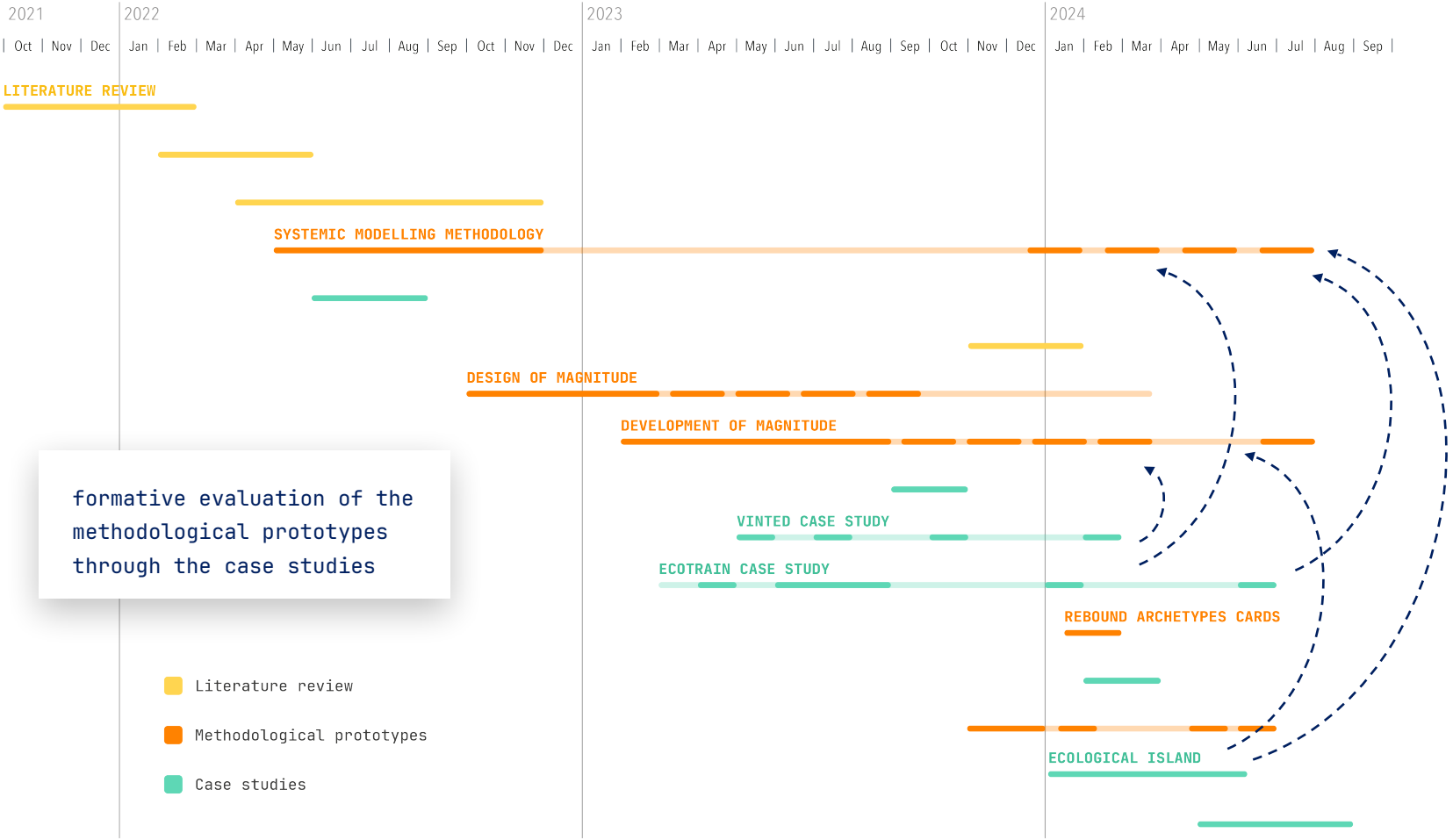
LITERATURE REVIEW
SYSTEMIC MODELLING METHODOLOGY
DESIGN OF MAGNITUDE
DEVELOPMENT OF MAGNITUDE
VINTED CASE STUDY
ECOTRAIN CASE STUDY
REBOUND ARCHETYPES CARDS
ECOLOGICAL ISLAND
Literature review
Methodological prototypes
Case studies


2021
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ECOLOGICAL ISLAND
formative evaluation of the methodological prototypes through the case studies
Literature review
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Case studies

Main case studies

Case study	Type	Time	Focus	Stakeholders	Data
Vinted	Real-world	Mid-way	Product/service design Business modelling	Designers	Existing survey
EcoTrain	Real-world	Ex-ante	Service design Political decisions	Political actors	Field study
Ecological island	Fictional	Prospective	Service design Political decisions	Researchers	Secondary data and hypotheses

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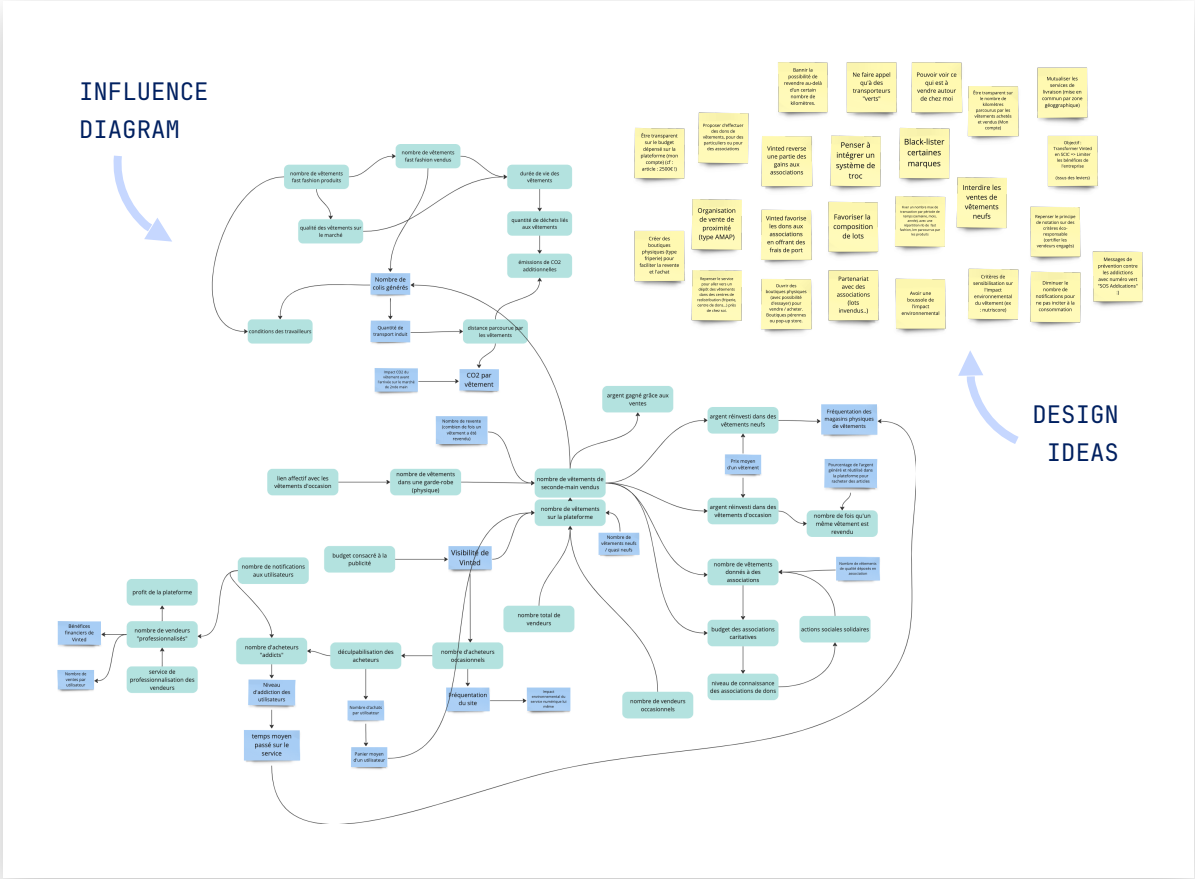
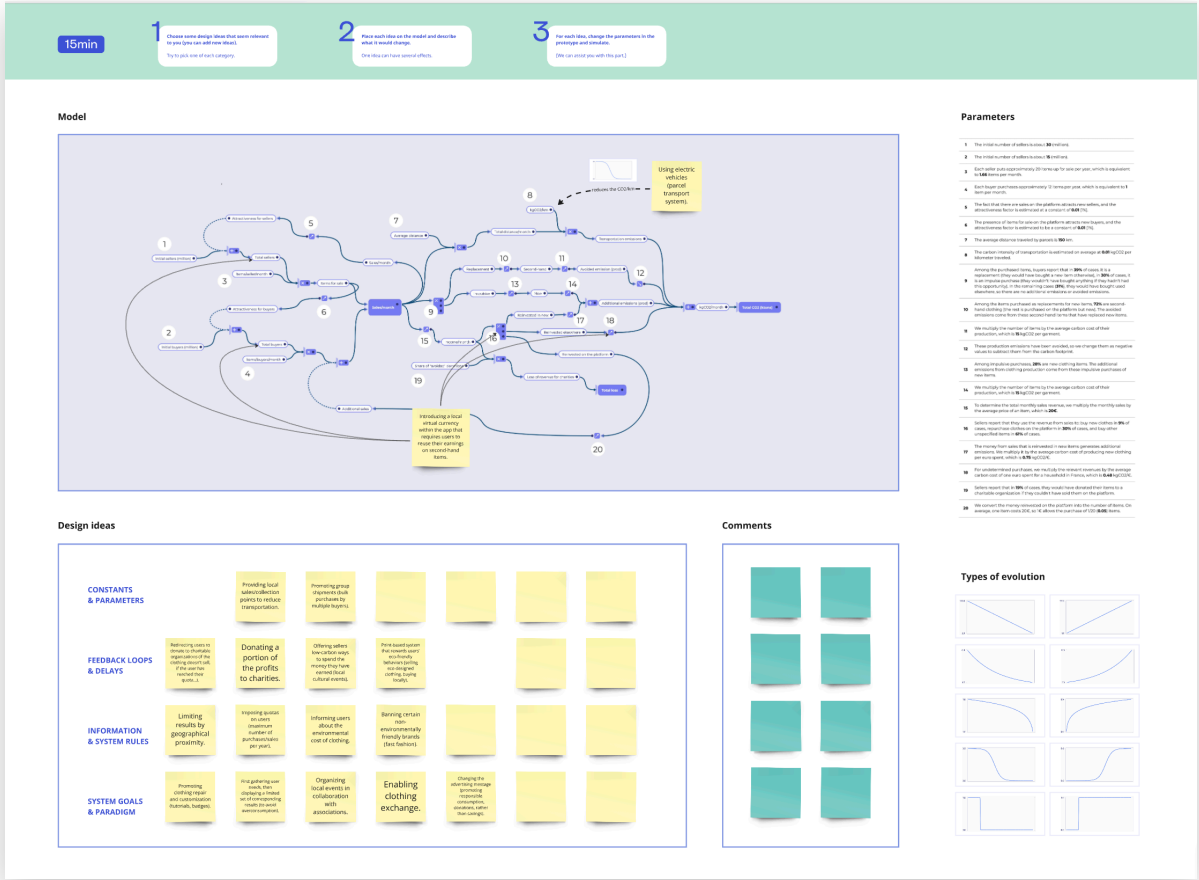
Vinted

mid-way designers
•
4 workshops
4 interviews



Vinted

mid-way
designers
•
4 workshops
4 interviews



Vinted

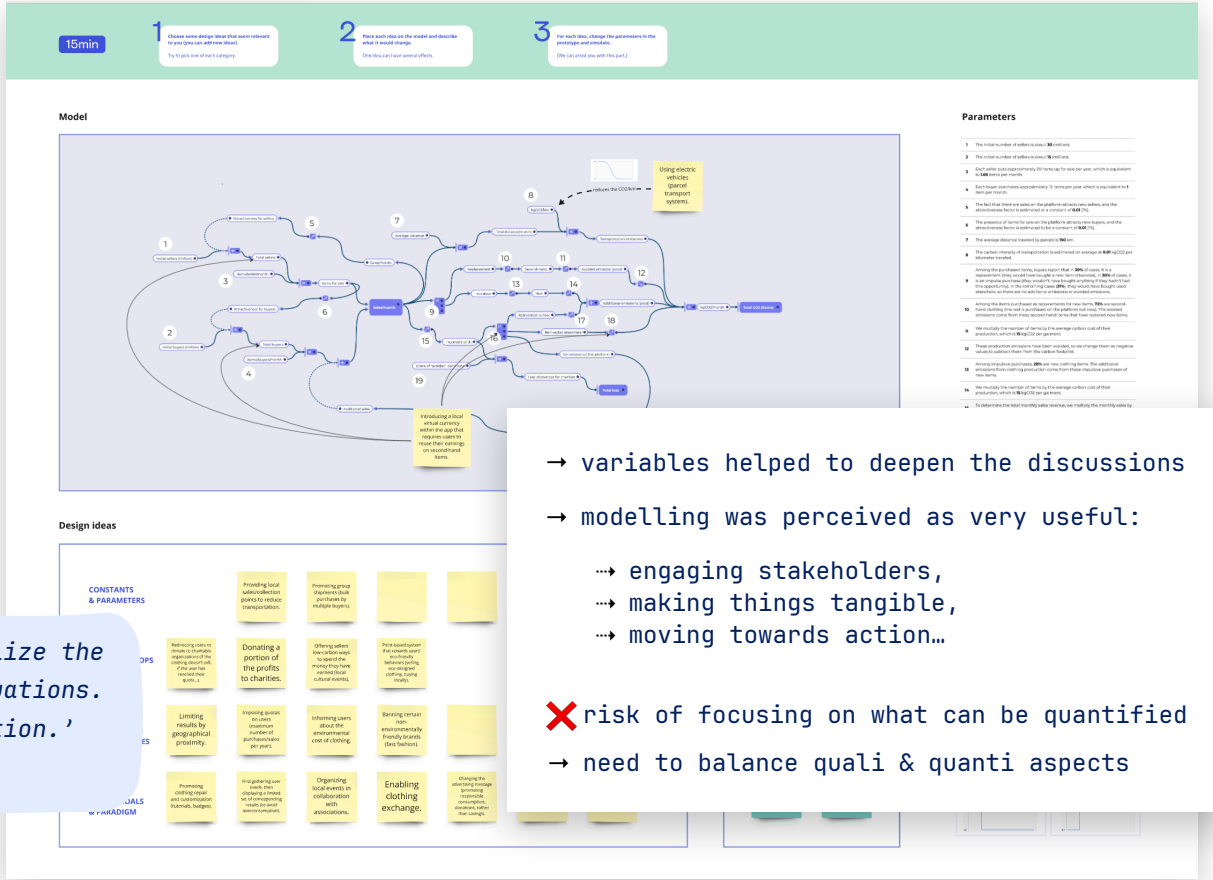
mid-way designers
•
4 workshops
4 interviews

Bulk purchases may reduce transport emissions, but do they lead to compulsive buying?

[Collective discussion]

'It allows us to concretely visualize the impact of actions and compare situations. […] that's the transition to action.'

[Designer D8]



→ variables helped to deepen the discussions

→ modelling was perceived as very useful:

⇢ engaging stakeholders,
⇢ making things tangible,
⇢ moving towards action…

❌ risk of focusing on what can be quantified

→ need to balance quali & quanti aspects

EcoTrain

ex-ante
political actors
•
4 workshops
1-day observations
1 focus group
9 interviews
1 quantitative survey

LA DÉPÊCHE

5° / 7° Toulouse

Rechercher

Journa

lundi 09 décembre 2024, Saint Pierre

Une étude sur l'écomobilité menée à Lectoure

EcoTrain

ex-ante
political actors
•
4 workshops
1-day observations
1 focus group
9 interviews
1 quantitative survey

→ new mobility project with a light electric train, using an abandoned railway line

→ anticipating (in)direct effects:

⇢ additional journeys,
⇢ real estate, employment…

→ specific field study & survey

→ follow-up study


LA DÉPÊCHE

5° / 7° Toulouse

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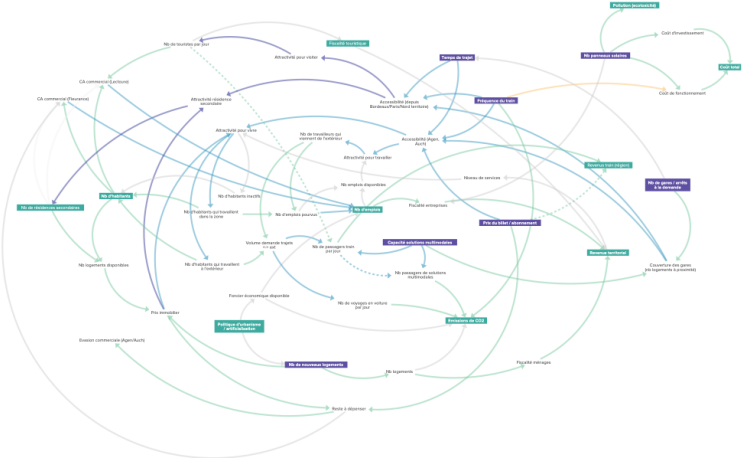
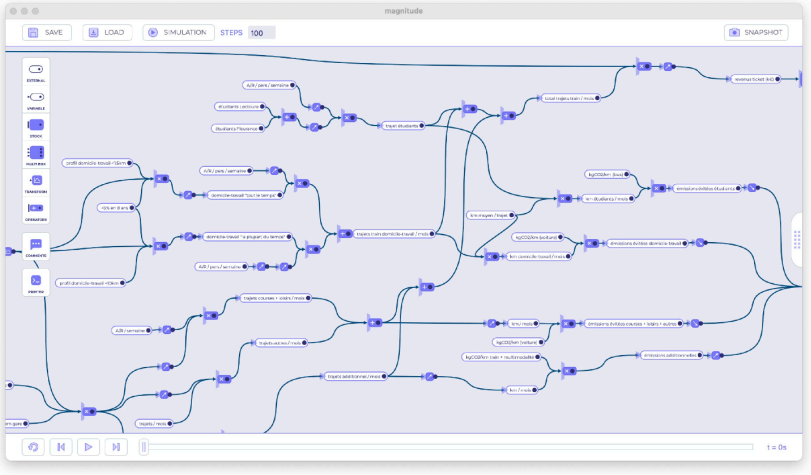




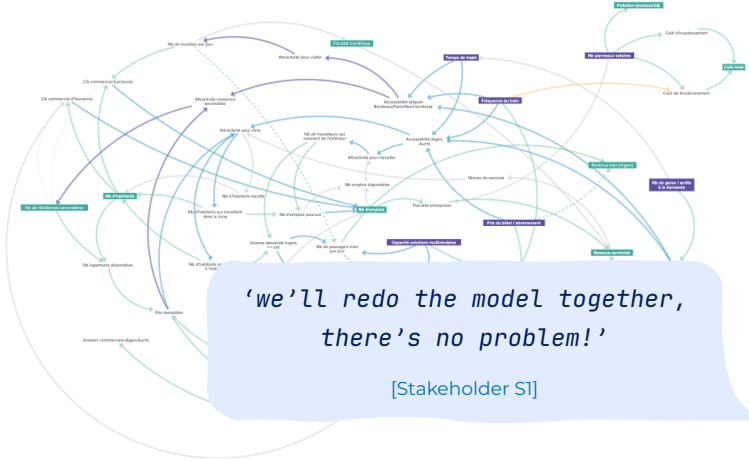
EcoTrain

ex-ante
political actors
•
4 workshops
9 interviews + focus group
1-day observations
1 quantitative survey

→ appreciated being involved in the process

→ very aware of the uncertainties

→ the model as a discussion tool



'we'll redo the model together, there's no problem!'

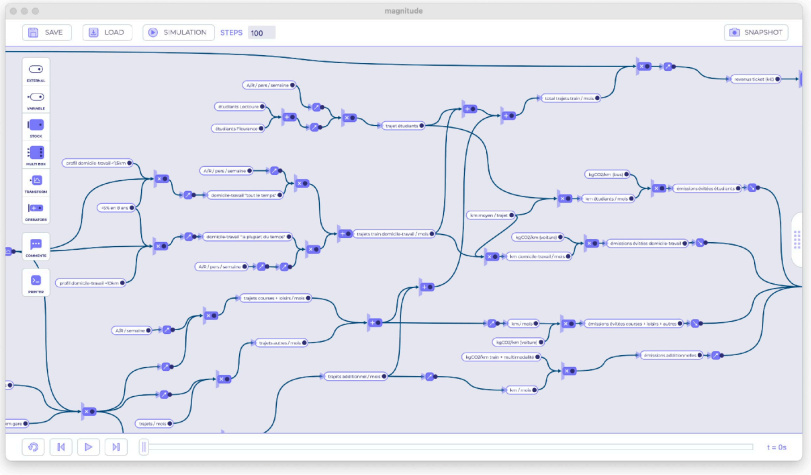
[Stakeholder S1]

'It's not the results […] obtained by the tool, that interests us, but the whole process.'

[Stakeholder S2]

'the good thing is that it's a decision-making support tool that we've built ourselves'

[Stakeholder S3]



Ecological island

prospective researchers

•

1 student

2 workshops

10 meetings

4 scenarios

Ecological island

prospective researchers
•
1 student
2 workshops
10 meetings
4 scenarios

→ reflection on possible future mobility scenarios

→ new version of the methodology

→ better balance the consideration of quali & quanti aspects

Ecological island

prospective researchers
•
1 student
2 workshops
10 meetings
4 scenarios

Alderney scenario

Alderney's only town concentrates the island's economic activity: as a result, some inhabitants from the rural areas of Alderney go shopping by car. Because the island is close to the continent, **medical emergencies can be easily and quickly transferred** to the closest regional hospital: the presence of a general practitioner is enough for the less urgent care, though specialized doctors are mainly available on the continent. A small school accommodates the young children living on the island. However, **pupils must commute to the continent from middle school on**. Because Alderney is small and close to the continent, the commute is easy and takes only a short amount of time. Small ferry boats and small aircraft frequently fly to and from the point of connection. These ferry boats are also used to import goods from the rest of the world.

Sark scenario

Jersey scenario

Guernsey scenario

Being a vast and isolated island, Guernsey is quite independent from the continent. The local infrastructures are well developed: all medical care can be delivered on site, and children can go to the island's school until their high school graduation. As for mobility, soft means of transportation – such as foot, bicycle, or even public transport – are preferred. The vehicles' load factor is high. The reason for this is the low frequency of the buses, which is not a problem because the timetables are adapted to the residents' daily commute: the frequency is adapted, most importantly in the early morning and in the late afternoon. The same goes for the transportation from and to the point of connection on the continent, which is linked to Guernsey by ferry or a regional aircraft.

Ecological island

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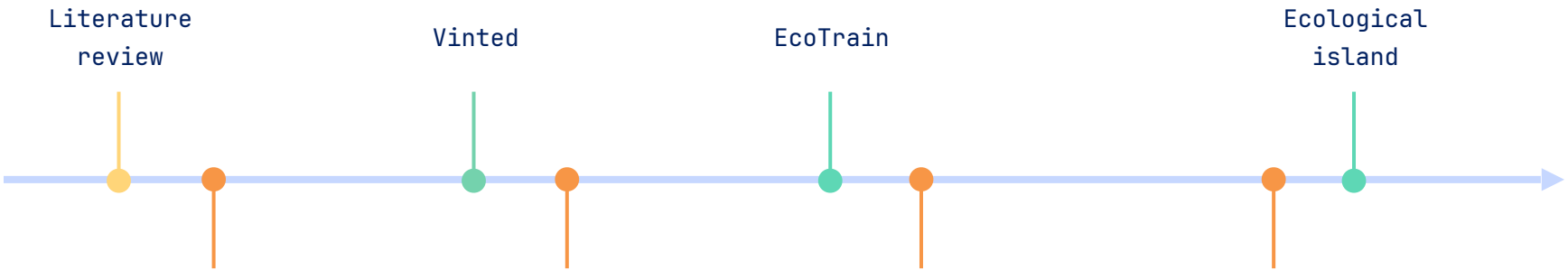
→ the methodology seems appropriate

→ exclusion of unrealistic hypotheses

→ importance of terminology

Evolution of the systemic modelling methodology



Systemic modelling V0

combining qualitative and quantitative tools

Systemic modelling V1

integrating into a design/decision process

Systemic modelling V1+

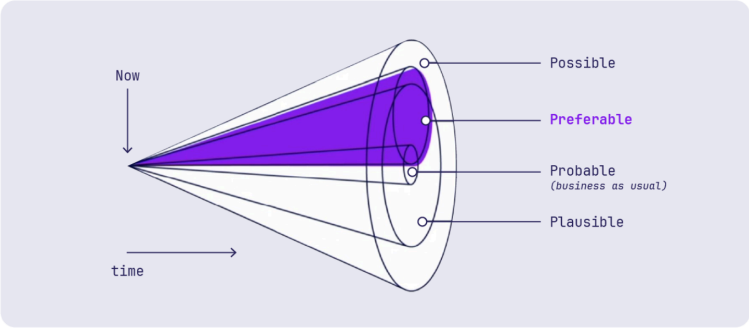
good practices for collecting and analysing the data

Systemic modelling V2

narrative scenarios as the glue between quali & quanti

Future scenarios for transportation

Purpose of the prospective scenarios



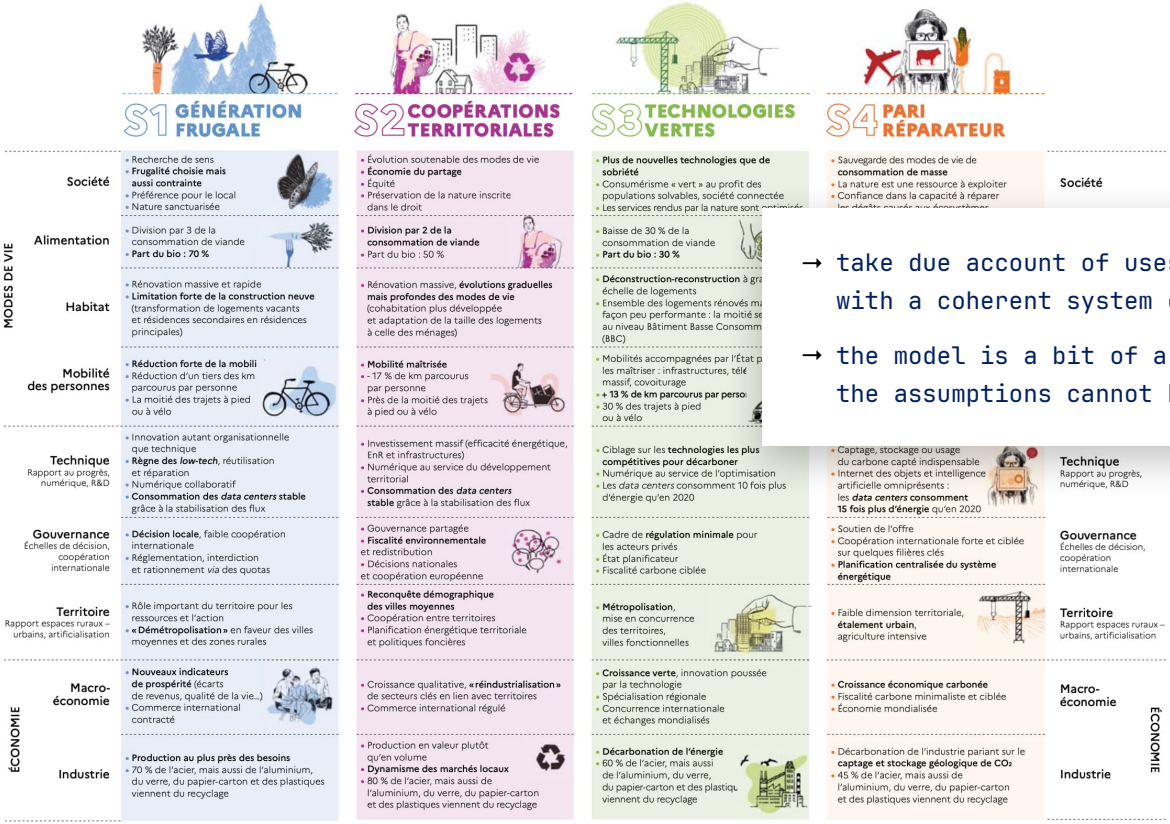
Futures cone, adapted from Hancock and Bezold (1994)

> Enable collective acculturation and debate.

> Guide innovation initiatives (appropriate to these futures).

> Stimulate strategic thinking (trajectory towards these futures).

Purpose of the prospective scenarios

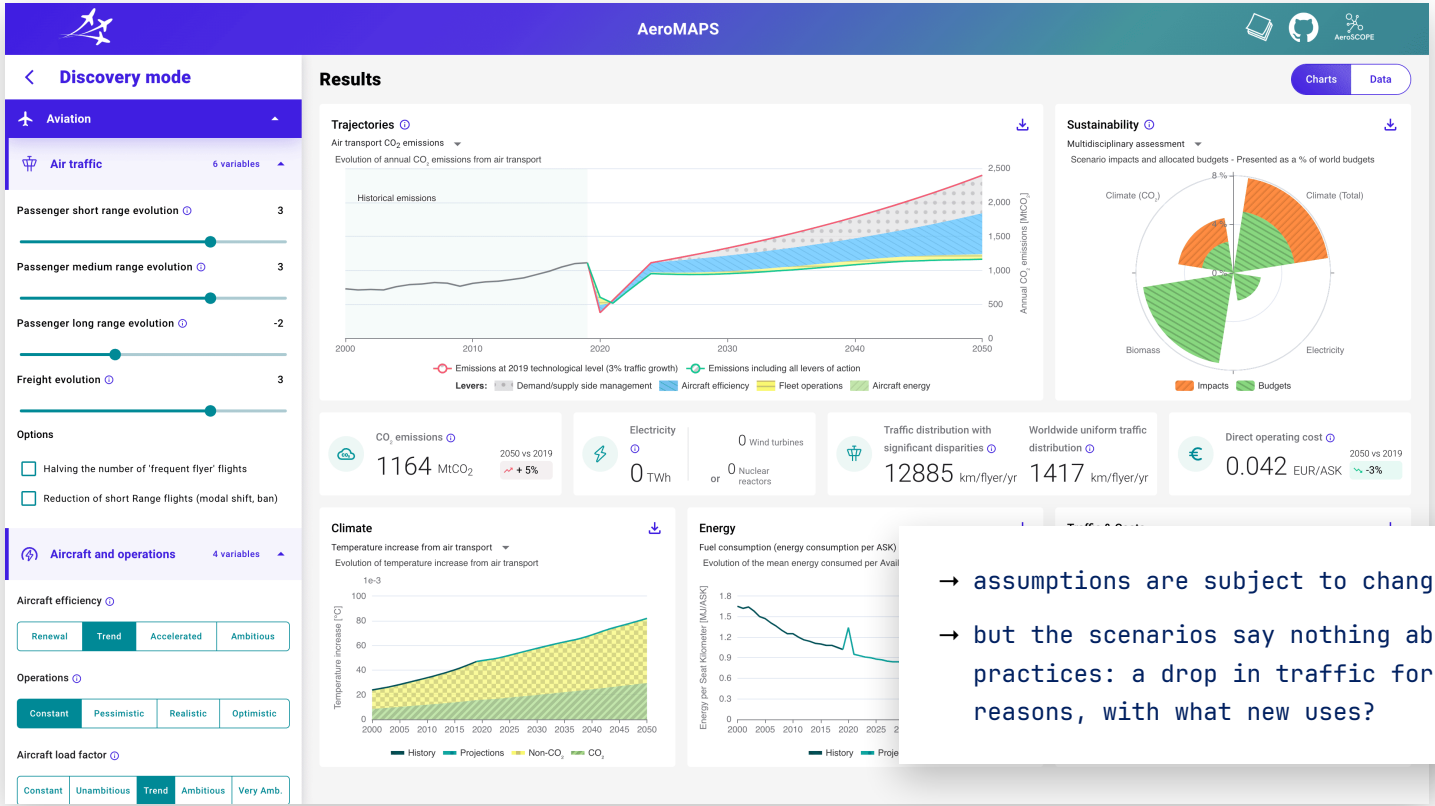


→ take due account of uses and practices, with a coherent system of values

→ the model is a bit of a 'black box': the assumptions cannot be questioned

ADEME. (2021). *Transitions 2050 - rapport* (tech. rep.). Agence de la transition écologique.

AeroMAPS

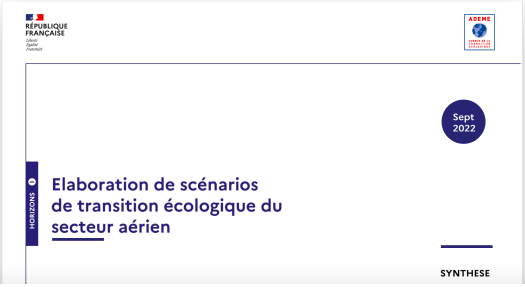


→ assumptions are subject to change

→ but the scenarios say nothing about practices: a drop in traffic for what reasons, with what new uses?

Planès, T., Delbecq, S., & Salgas, A. (2023). AeroMAPS: a framework for performing multidisciplinary assessment of prospective scenarios for air transport. Journal of Open Aviation Science, 1(1).

Scénarios de transition écologique du secteur aérien [ADEME]



S0 « Scénario de référence »	SA Scénario « Rupture technologique »	SB Scénario « Modération du trafic »	SC Scénario « Tous leviers »
La société se développe selon les tendances actuelles, sans modération du trafic ou déploiement de technologies allant au-delà des technologies déjà maitrisées actuellement.	**Des investissements importants sont réalisés dans l'aéronautique et la production de CAD, afin de conserver un niveau de trafic élevé et de permettre au secteur de développer son activité.**	**Des mesures de modération du trafic et les CAD sont mobilisés pour minimiser les émissions cumulées entre 2020 et 2050 et réduire nettement les émissions d'ici 2030.**	**La décarbonation du secteur s'appuie sur tous les leviers disponibles afin de réduire le recours à des technologies de rupture non-matures aujourd'hui et d'augmenter l'acceptabilité des mesures de modération du trafic.**
Absence de rupture technologique : les flottes sont modernisées via le remplacement des avions en fin de vie par les avions les plus performants disponibles aujourd'hui.	Des ruptures technologiques et de fortes améliorations des opérations permettent de diminuer significativement la consommation énergétique des avions à partir de 2035. L'avion court-courrier à hydrogène voit le jour en 2035.	Les nouveaux avions bénéficient des améliorations technologiques incrémentales. L'avion à hydrogène n'est pas développé.	Des progrès technologiques et des améliorations des opérations permettent de diminuer la consommation énergétique des avions à partir de 2040.
Les avions continuent d'utiliser quasi …arburants	Les CAD sont progressivement mobilisés grâce à des efforts d'investissement très importants (et ce plus particulièrement sur les électrocarburants).	Les CAD sont progressivement mobilisés grâce à des efforts d'investissement importants (et ce plus particulièrement sur les biocarburants).	Les CAD ne sont pas produits en quantité suffisante pour couvrir la demande. Le premier avion court-courrier à hydrogène est commercialisé en 2040.
…ons reste …u prix du … par les …'efficacité … par le	L'utilisation de technologies plus onéreuses et des CAD renchérit rapidement le coût des vols à partir de 2035.	L'utilisation de CAD augmente le coût des vols à partir de 2030. Cette hausse s'accélère à partir de 2035.	L'utilisation de technologies plus onéreuses et des CAD renchérit progressivement le coût des vols.
…l'avion, ce …ation forte	La croissance du trafic aérien est soutenue, mais infléchie par la hausse des coûts des vols, à partir de 2030.	Le trafic est contraint par des leviers fiscaux et réglementaires dans l'optique de limiter les émissions du secteur, et ce dès 2023. Il est également limité par la hausse du prix des billets, à partir de 2030. Il diminue donc entre 2023 et 2030, est stable jusqu'en 2045, puis remonte légèrement à partir cette date.	Les mesures de modération du trafic et la hausse du prix des billets conduisent à une faible hausse du trafic.

→ 'black box' model

→ little information on usage: reasons for the drop in traffic, new flying practices, interfaces with other modes of transport, etc.

ADEME. (2022). *Élaboration de scénarios de transition écologique du secteur aérien* (tech. rep.). Agence de la transition écologique.

A systemic approach to new practices of mobility

> What are the current and future rebound effects of the aviation and transport sector? (Cobra effect, Blablacar…)

> Who is responsible for thinking about them and tackling them?

> Could we combine AeroMAPS with an investigation into usage and practices to develop prospective scenarios?

> What would be the methodological process for building prospective scenarios? (including other modes of transport)

> Could we use it as a democratic consultation tool?

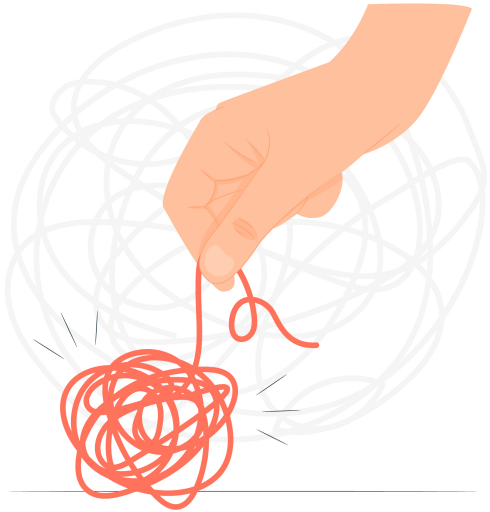
> Could this help with the difficult question of absolute sustainability?

Discussion on modelling

'All models are approximations. Assumptions, whether implied or clearly stated, are never exactly true. *All models are wrong, but some models are useful.* So the question you need to ask is not "Is the model true?" (it never is) but "Is the model good enough for this particular application?"'

George E. P. Box

- Why do we build a model and scenarios?
- Who is going to use them and why?
  - opening up the imagination, making decisions, etc.
- What is the appropriate methodology for building a model?
  - What scope, what type of model?
  - Emergent phenomena, *bounded rationality* (Simon)
- What are the risks?
  - How can we prevent a model being used for purposes other than those for which it was designed?
  - How can uncertainties be accounted for?
  - Responsibility as a model designer



Collective modelling as a means to engage with a complex situation

Thank you!

Publications

Long paper	Bornes, L.*, Smith M.*, Bates O., Blair G., Letondal C., and Vingerhoeds R. (2024, October). Rebound Archetypes: A Card-based Tool to Help Designers Think Through the Rebound Effects when Designing for Sustainability. In Proceedings of Relating Systems Thinking and Design (RSD13) Symposium. * Authors contributed equally
Long paper	Bornes, L., Letondal, C., Vingerhoeds, R. (2024, July). Systemic Sustainable HCI: Integrating Collaborative Modeling into a Design Process to Address Rebound Effects. In Proceedings of the 2024 ACM Designing Interactive Systems Conference.
Long paper (best paper award)	Ekchajzer, D.*, Bornes, L.*, Combaz, J.*, Letondal, C., Vingerhoeds, R. (2024, June). Decision-Making under Environmental Complexity: Shifting from Avoided Impacts of ICT Solutions to Systems Thinking Approaches. In Proceedings of the 11th International Conference on ICT for Sustainability. * Authors contributed equally
Long paper	Bornes, L., Letondal, C., Vingerhoeds, R. (2022, October). Could Systemic Design Methods Support Sustainable Design of Interactive Systems?. Proceedings of Relating Systems Thinking and Design (RSD11) Symposium.
Short paper (journal)	Bornes, L., Letondal, C., & Vingerhoeds, R. (2023). Understanding the Indirect Effects of Interactive Systems Within Systems of Systems. INSIGHT, 26(4), 18-21.
Short paper	Letondal, C., Laplace, I., Druot, T., Bieder, C., Pauchet, S., & Bornes, L. (2024, April). Approches alternatives pour penser et construire le futur du transport aérien : exemples d'expériences pédagogiques. In Entretiens de Toulouse.
Short paper	Letondal, C., Bornes, L., Garcia, J., Duchevet, A., Conversy, S., Pauchet, S., & Vo, D. B. (2024, March). Un cockpit pour l'aviation du futur ? Par quel prisme de l'IHM approcher la question ?. In IHM'24-35e Conférence Internationale Francophone sur l'Interaction Humain-Machine.
Extended abstract (CHI Doctoral consortium)	Bornes, L. (2023, April). A Methodology and a Tool to Support the Sustainable Design of Interactive Systems: Adapting systemic design tools to model complexity in interaction design. In Extended Abstracts of the 2023 CHI Conference on Human Factors in Computing Systems (pp. 1-5).
Workshop	Bornes, L., Letondal, C., & Vingerhoeds, R. (2023, October). Using a Quali-Quantitative Modelling Tool to Explore Scenarios for More-Than-Sustainable Design. In Proceedings of Relating Systems Thinking and Design (RSD12) Symposium.
Poster (best poster award)	Best poster award at ISAE PhD day. (2023, June).
Poster (best poster award)	Best poster award at a AFIS (Systems engineering) conference. (2022, December).

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V. C. Coroamă, P. Bergmark, M. Höjer, and J. Malmodin, “A Methodology for Assessing the Environmental Effects Induced by ICT Services – Part I: single services,” Proceedings of the 7th International Conference on ICT for Sustainability. ACM, Jun. 21, 2020. doi: 10.1145/3401335.3401716.

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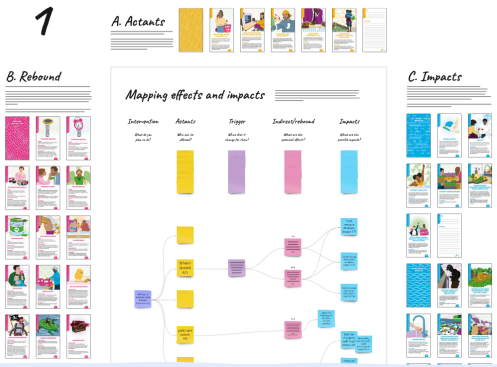
Rebound Archetypes

Creative Commons

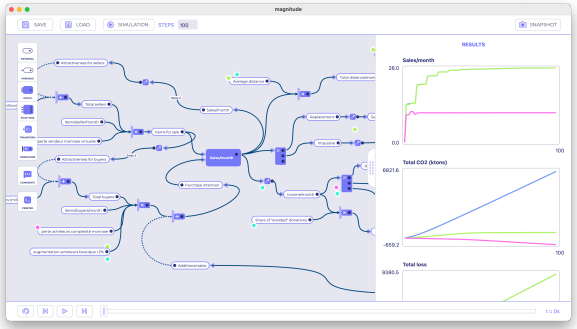


In French & English:
> Cards to print
> Rules/guidelines
> Miro template for online workshops

https://lii.enac.fr/projects/rebound-archetypes-cards/

Magnitude

Open/free access



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> guidelines (English)
> examples of models…

https://lii.enac.fr/projects/magnitude/