THE FUTURE OF OUR PAST

TU Delft Delft University of Technology
Faculty of Architecture
and the Built Environment

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May 2023

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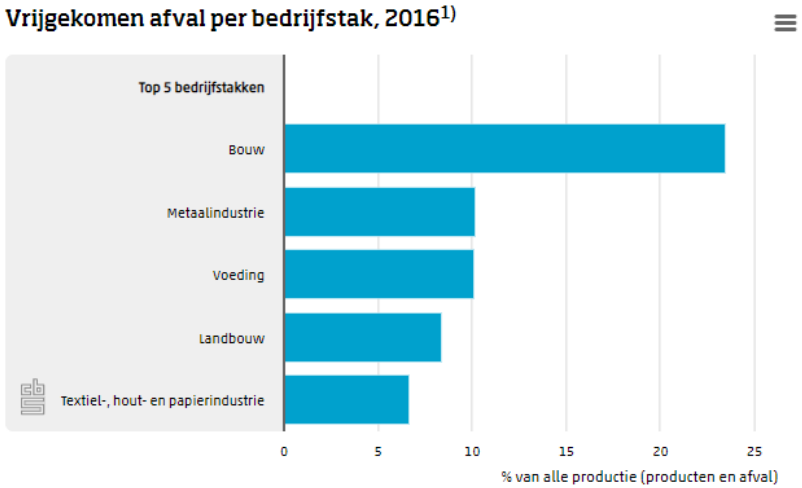
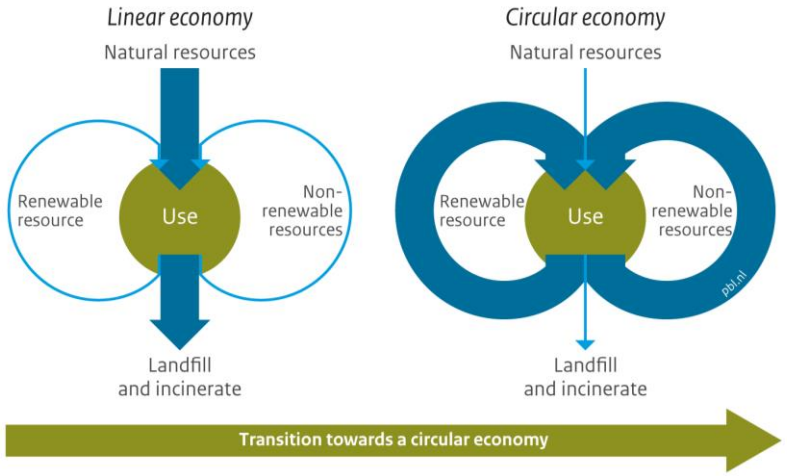
Current implementation of circular economy strategies in the adaptive reuse of heritage buildings and mitigating remaining barriers

Problem Statement





Nederland circulair in 2050

Leegstand van rijksmonumentale niet-woningen, 2019

31-1-2020 12:00

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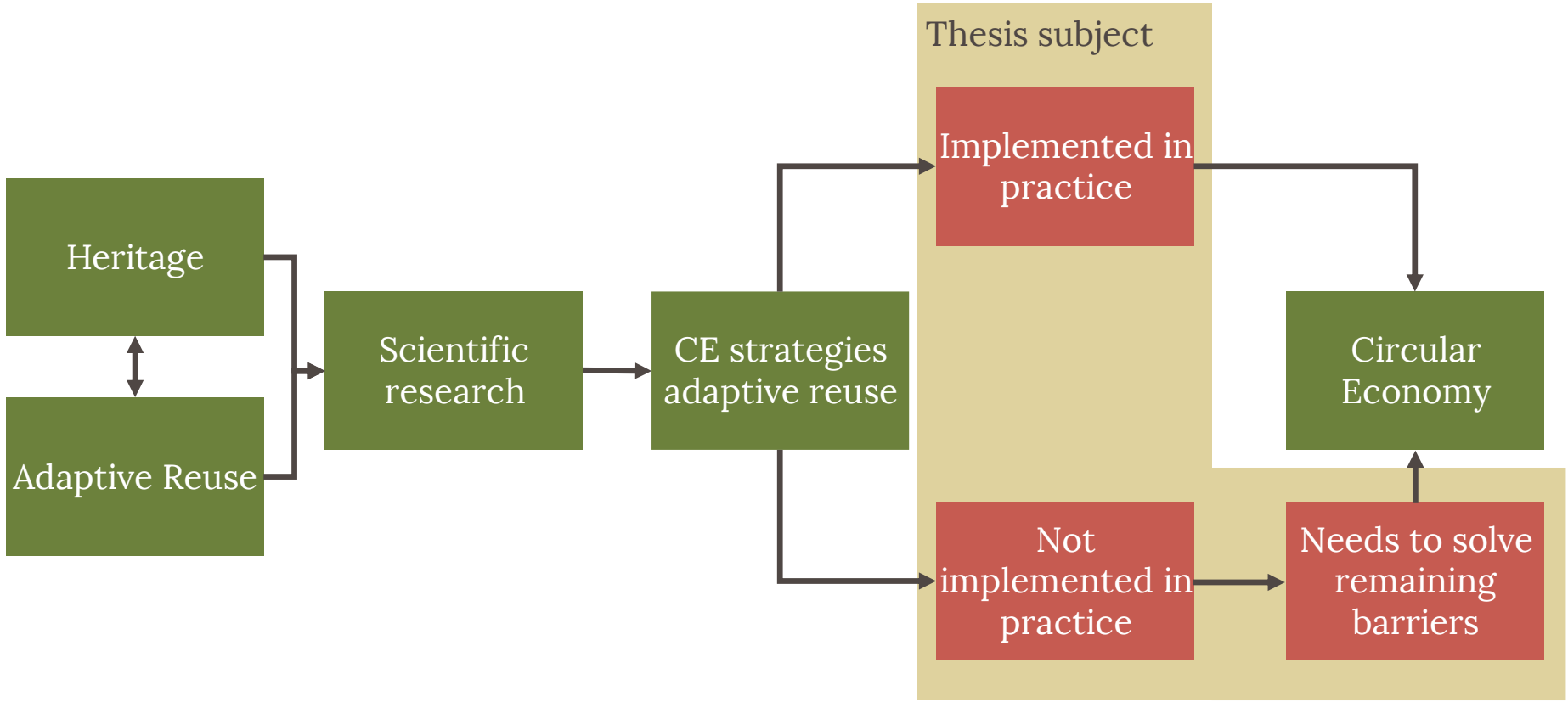
Why heritage?

Research design



Research question

What **circular economy strategies** are currently implemented in the **adaptive reuse of heritage buildings** and how can the **remaining barriers** be **mitigated** in order to move towards the **circular economy?**

Sub-questions

SQ 1. How are circularity, adaptive reuse, and heritage defined within the context of the built environment?

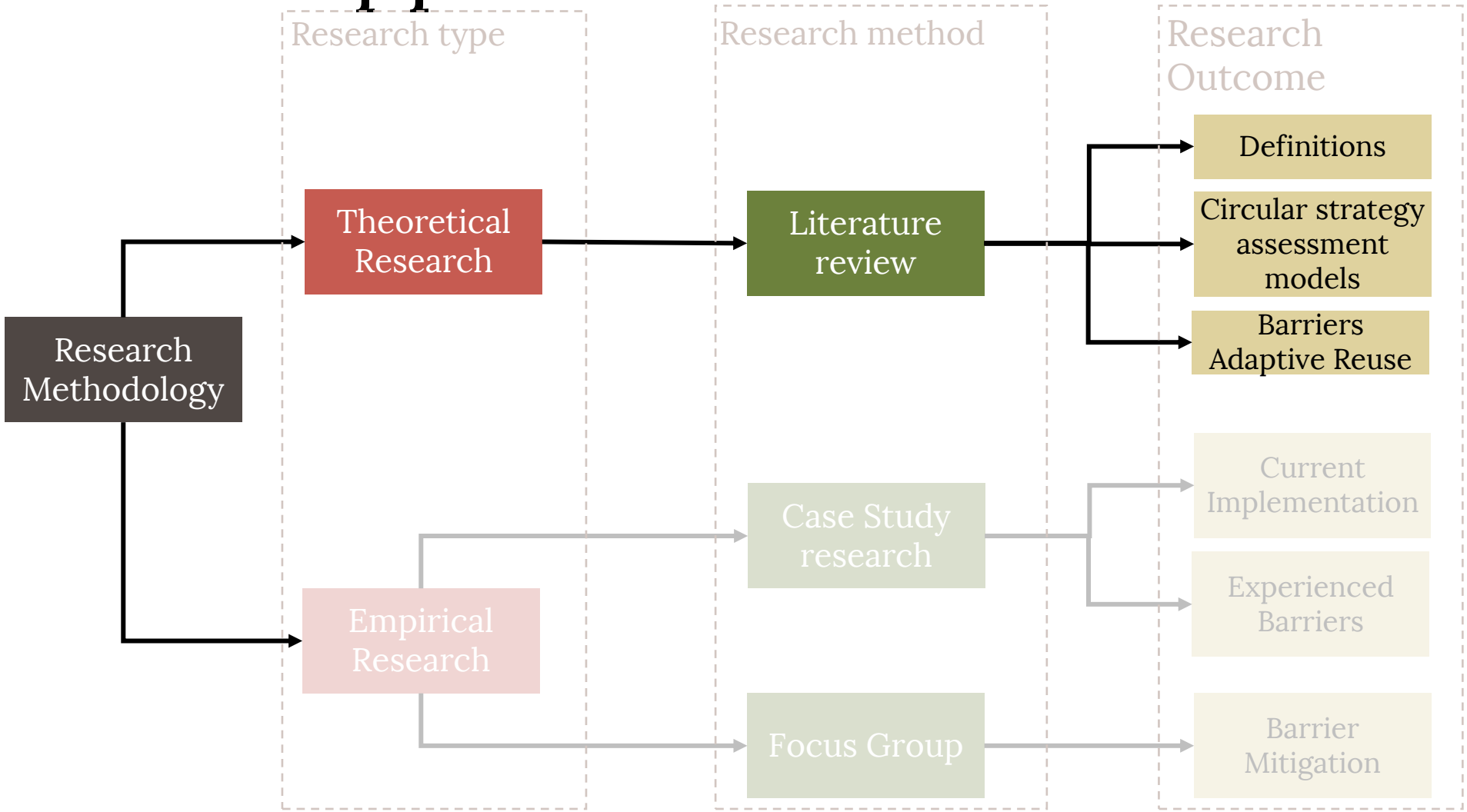
SQ 2. What circular economy strategy assessment models exist for adaptive reuse projects of heritage buildings?

SQ 3. What are the barriers related to circular construction and adaptive reuse of heritage buildings?

SQ 4. What circular economy strategies have been implemented in adaptive reuse heritage projects from practice?

SQ 5. How can the barriers be mitigated for future implementation in order to help the transition towards the circular economy?

Research approach



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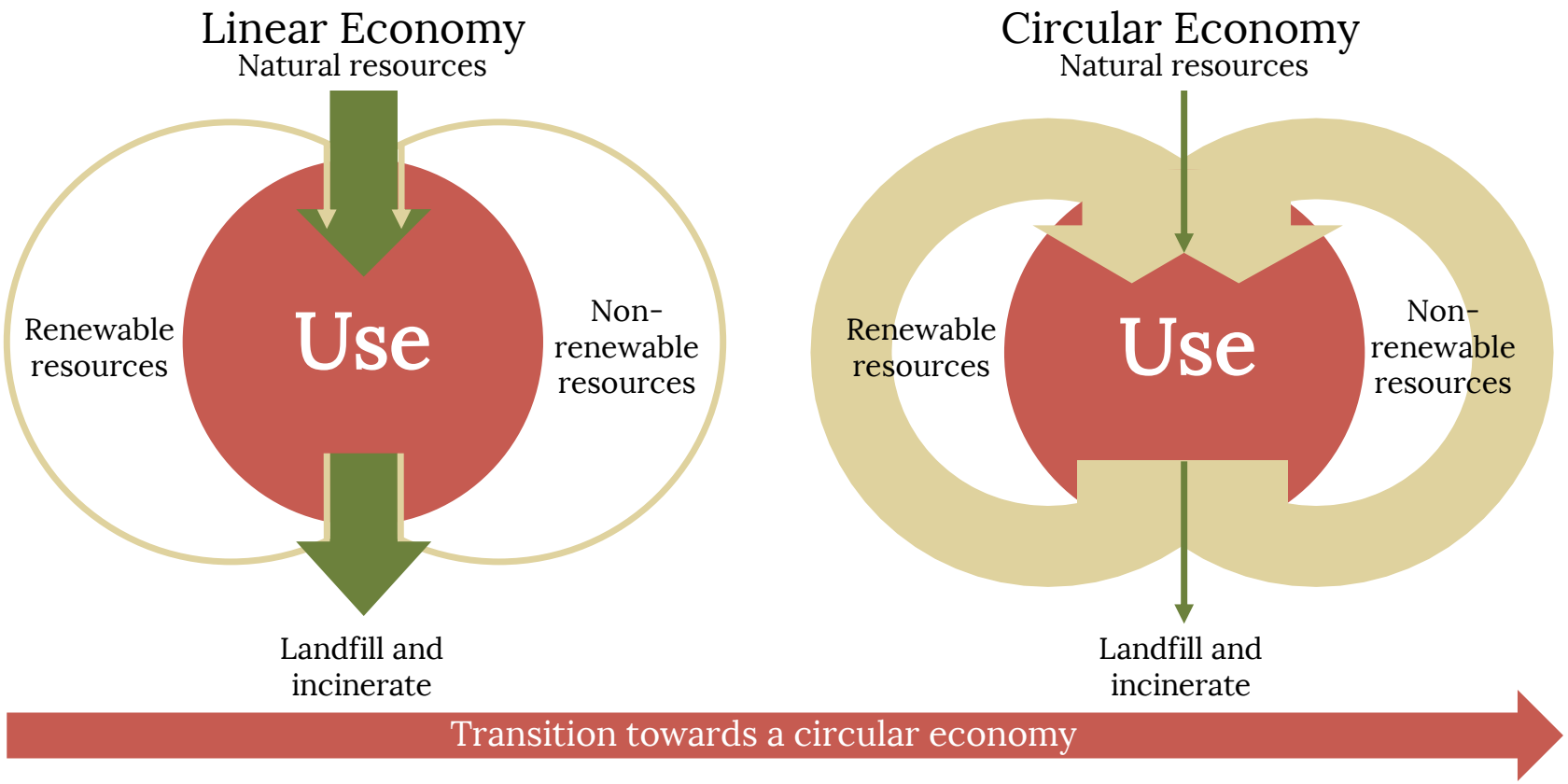
Literature review - circular economy



Literature review - adaptive reuse

Literature review - heritage

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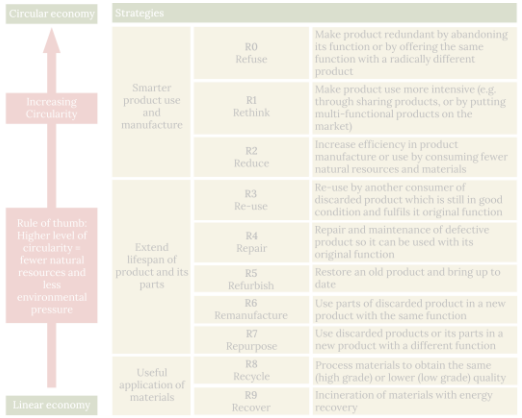
Literatuur review – Circular strategy assessment models



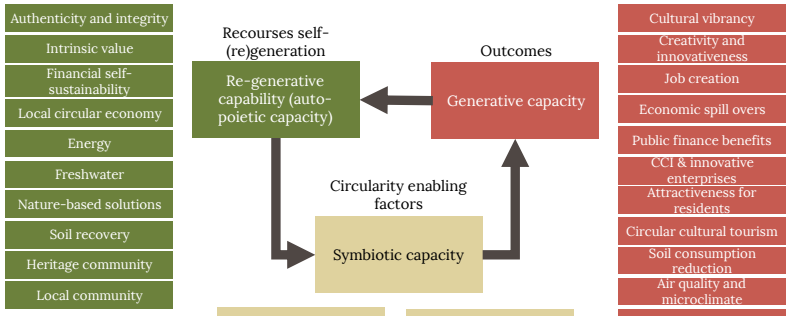
R-ladder model (Potting et al., 2017)

CE Principles	Description
Regenerate	Use renewable resources, such as energy and materials, and restore depleted biological resources to the biosphere
Share	Utilize items to their fullest potential by sharing privately held goods, reusing them, and prolonging their useful lives through maintenance, repair, and durable design
Optimise	Enhancing product effectiveness and efficiency while cutting down on or doing away with waste
Loop	Keep parts and materials in closed loops and give internal ones priority
Virtualise	Offer virtual tools and other services
Exchange	Substitute more modern, renewable materials and technology for the oldest ones now being used

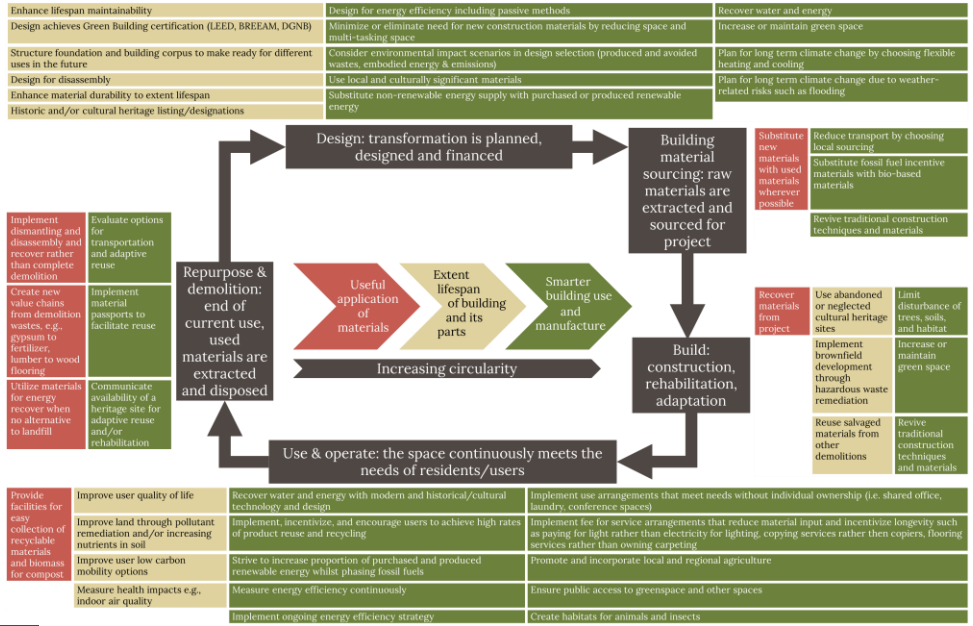
RESOLVE model
(McKinsey & Company, 2016)

Key environmental impact indicators for ARCH			
1. Indicators of direct reduction to new natural materials extraction due to the adaptive reuse	2. Indicators of direct reductions to energy use due to the adaptive reuse	3. Indicators of direct environmental improvements due to the adaptive reuse	4. Indicators of indirect reductions to energy use or pollution due to the adaptive reuse
Maintain embodied energy in reused concrete, stone, brick, steel, etc. (CO2 equiv. GHGs per ton avoided or tones avoided/reused)	Greenhouse gas emissions (CO2 equiv. GHGs tons/year)	Reductions to air emissions including CO2, nitrogen oxides, (Nox), sulphur oxides (SOx), and particulate matter	Maintain embodied energy in reused concrete, stone, brick, steel, etc. (CO2 equiv. GHGs per ton avoided)
Increase water efficiency/fresh water consumption (kilolitres/person/year)	Increase energy efficiency/ consumption per (megawatt hours or kilojoule/user/year)	Improve water quality measured as eutrophication potential based on nutrient loads (phosphorous or nitrogen g/litre of dissolved oxygen)	Limit land use change (farmland maintained or reduction to urban sprawl in hectares)
Reduce C&D waste to landfill through recovery and reuse on or off-site (cubic meters)	Increase amount of non-renewable vs. renewable energy use (megawatt hours or kilojoules)		Indirect emission reductions due to the adaptive reuse e.g., reduction in vehicle use (CO2 equiv. GHGs per year avoided)
Increase land use efficiency due to the adaptive reuse (square meter reductions to space requirements of new purpose)			

Key circular environmental indicators (Foster & Kreirin, 2021)



Cultural heritage adaptive reuse (CHAR) database of criteria (Bosone et al., 2021)



Circular economy strategies for adaptive reuse of cultural heritage buildings to reduce environmental impacts (Foster, 2020)

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Literature Review - barriers

Drivers	
Governmental	Policy support
	Regulatory reform
Economic	Financial incentives
	Circular business models
	Tools to measure value of materials and products
	Information metrics
Technological	Web-based innovation
	Efficient designs
	Development of enabling technology
	Technology to enable close-loop materials
Environmental	Development of environmental assessment metrics
Societal	Recognition
	Support from demand network
	Collaboration
	Networking
	Multi-stakeholder connections
Behavioural	Leadership
	Company environmental culture
	Personal knowledge
	Intrinsic motivation

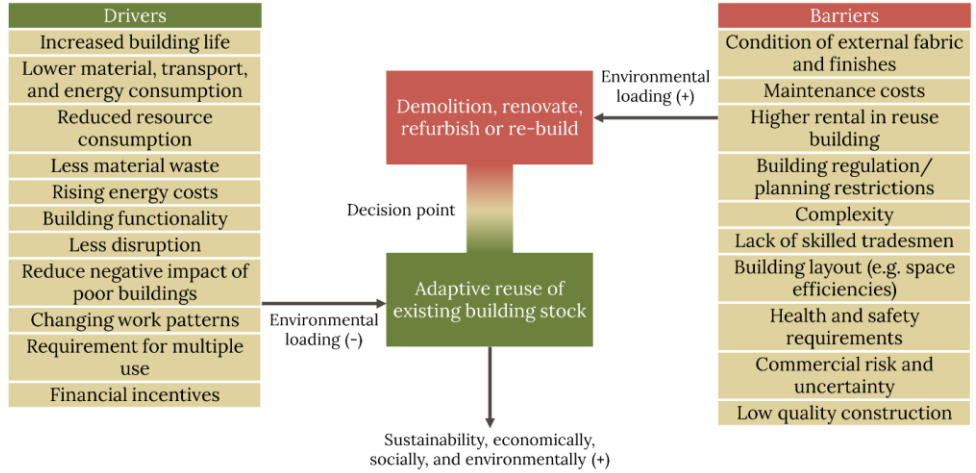
Circular initiatives	
R0 Refuse	Non-reusable materials
	Hazardous materials
	To use disparate binders
R1 Rethink	Processes using R-strategies
	Business models (PSS)
R2 Reduce	Consumption of new materials
	Non de-constructable constructions
R3 Reuse	Of components
R4 Repair	Entire constructions
	Constructions elements/components
R5 Refurbish	Older constructions (renovation)
	Structural elements
R6 Remanufacture	Resource from construction components
R7 Repurpose	Materials from outside the construction sector
	Entire buildings for residential housing
R8 Recycle	Materials for larger components
R9 Recover	Energy from materials
	Materials after incineration to be used as secondary raw materials

Barriers	
Governmental	Obstruction laws and regulations
	Lack of regulation and laws
	Lack of regulatory mechanisms
Economic	High upfront costs
	Inadequate financial resources
Technological	Technical challenges related to material recovery
	Lack of adequate technology
	Lack of standardisation
	Fragmented and linear supply chain
Environmental	-
Societal	Lack of knowledge and engagement throughout the value chain
	Lack of collaboration
Behavioural	-

Drivers and barriers to circular initiatives (adapted from Springvloed, 2021)

Challenges to adaptive reuse	
Environmental	Attaining the desired levels of standards
	The existence of hazardous materials
Social	Being on the heritage list
Economic	Lack of financial support
	High costs of adaptation
Legal	Receiving approvals for any work on heritage listed buildings
	Compliance with building codes and regulations
	Compliance with heritage guidelines
	Being on the heritage list
Political	Local government support
Physical	Finding a suitable function
	Lack of accurate drawings and information
	Poor quality of the building
	Poor physical and structural condition of the building
Locational	Complying with parking norms
Technical	Improvement of technical aspects of existing building
	Providing disability access
	Providing required performance standard and preserving the visual quality
	Installation and upgrade of mechanical and electrical systems
	Lack of experience and knowledge
	Specific construction techniques and materials in existing building
	Lack of skilled tradesmen

Challenges to adaptive reuse (adapted from Yazdani & Wilkinson, 2021)



Drivers and barriers of adaptive reuse (adapted from Bullen & Love, 2011)

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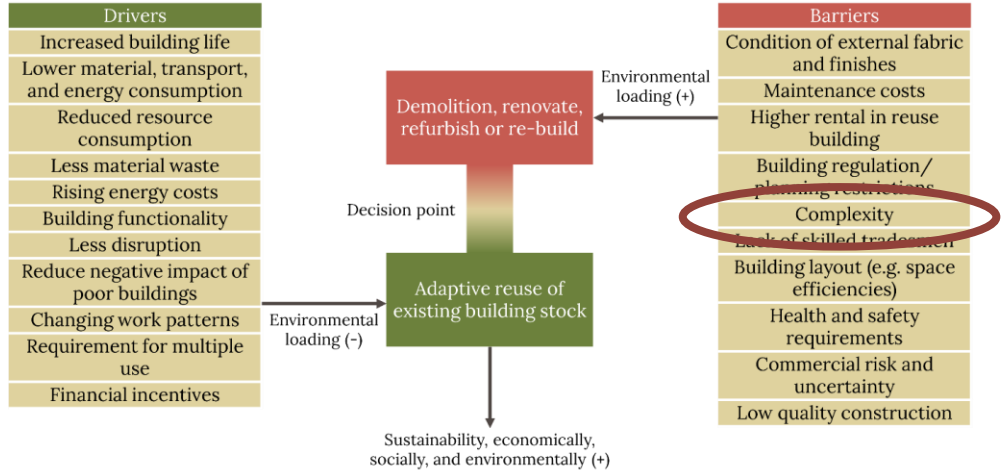

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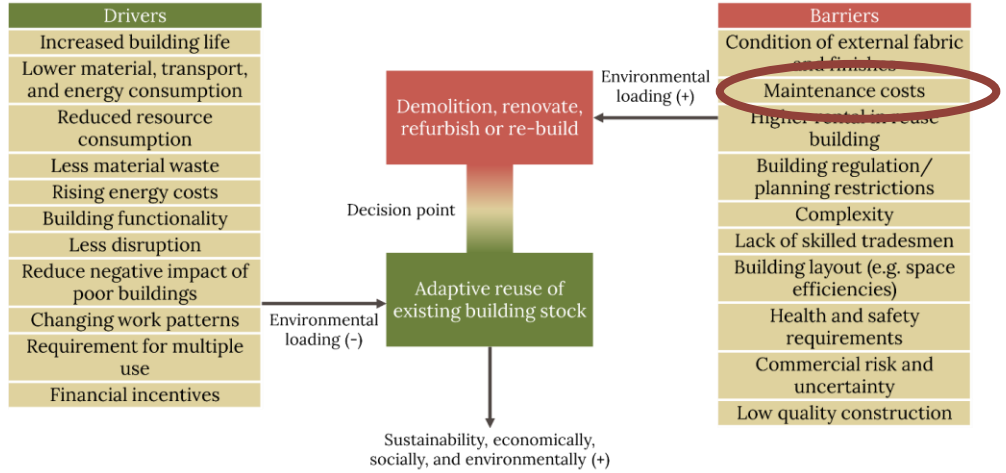

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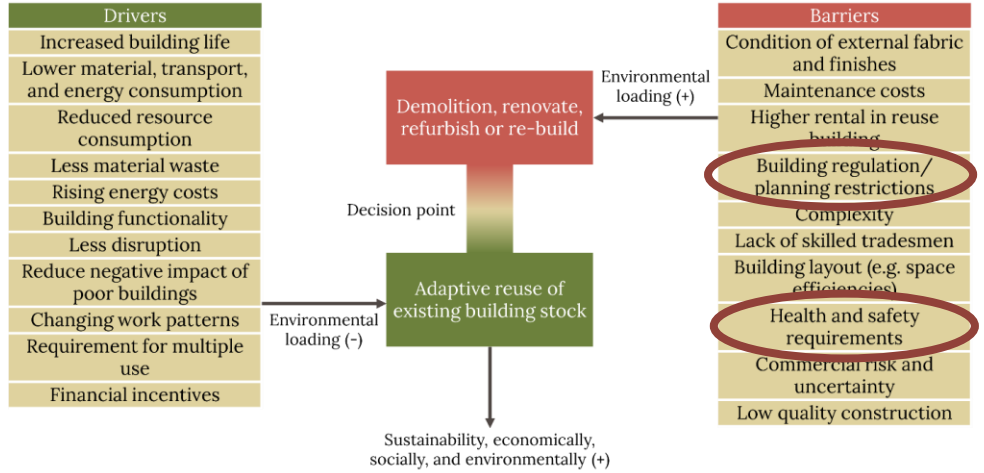

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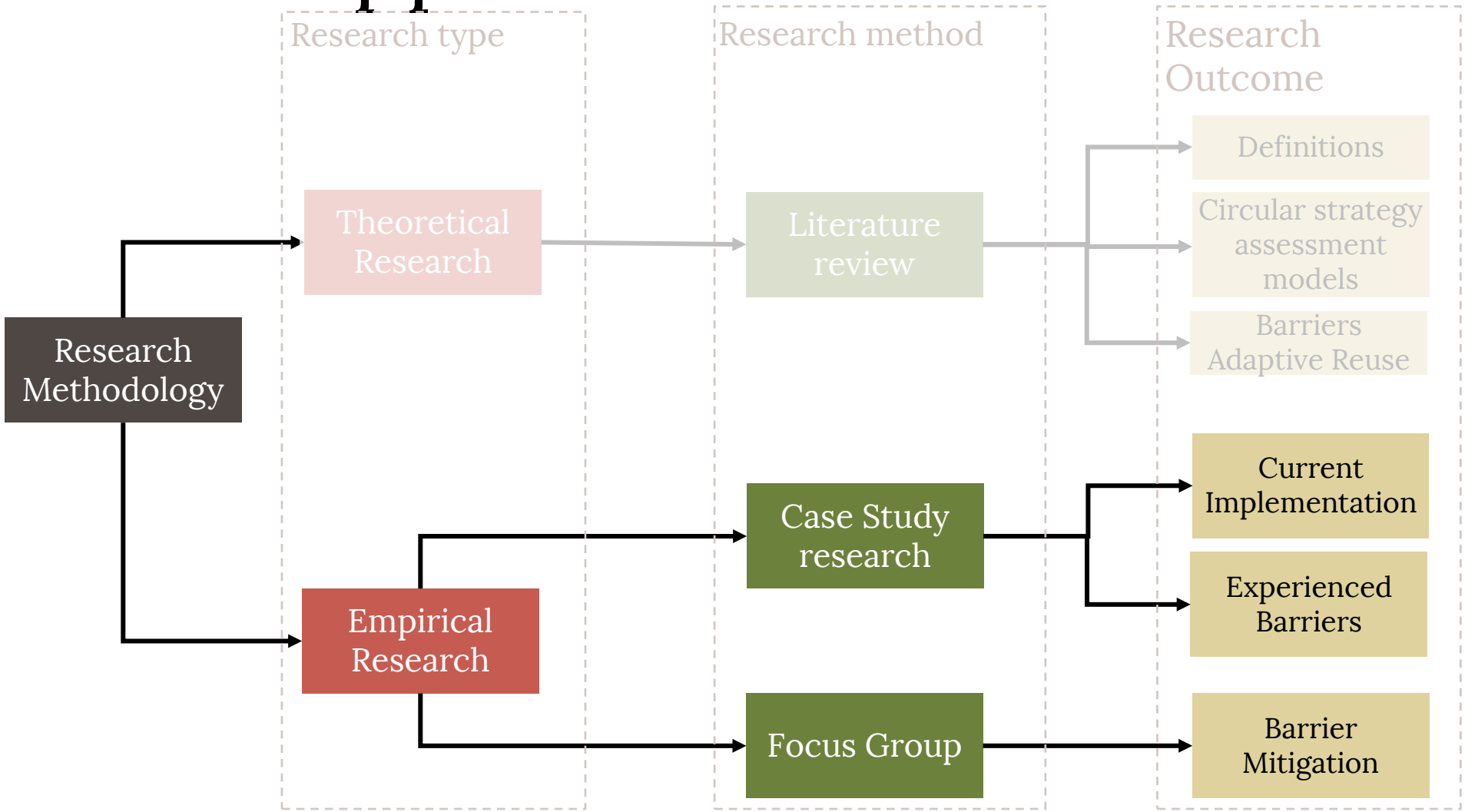

Case study – projects

- Vincentius – Udenhout
- Veerhuis – Rotterdam
- Oudezijds Voorburgwal 136 – Amsterdam
- Het Zuiderziekenhuis – Rotterdam
- Groot Tuighuis – ‘s-Hertogenbosch

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- Site visitation
- Document analysis
- Interviews

Case study – interviews

- Contractor – plan developer / project leader
- Client
- Architect

	Contractor	Client	Architect
Vincentius	✓	✓	– ✓
Veerhuis	✓	✓	✗
Oudezijds Voorburgwal	✓	✓	✗
Het Zuider	✓	✓	✓
Groot Tuighuis	✓	✓	✓

Interview goals

- How do different stakeholders define the circular economy?
- What circular economy strategies are currently implemented?
- What barriers are experienced?

Definitions

Interview results

Circular Economy

Interview results – Contractor

"For me, the circular economy is an economy in which there is basically no waste. waste no longer exists, because everything is in a circular flow so and only circles without linear processes or degrading processes where waste is created. The circular economy is basically that everything keeps circulating. Yes"

"The circular economy is actually what I think I said at the time, rather than linear process that creates waste. A circular economy has no waste and everything is actually circular in a circle. Everything just goes around, so every product does not become waste, it just becomes a product reused. Material also retains its value, is not degraded. That to me is a full circular economy"

"Nice question. Yes, when I look at circularity. Then I think of natural materials, materials that are pleasant for myself as a human being that have less burden or impose less burden on my environment, then I do think of something that I can use in a in a reuse still Maybe in the same or in a different form. Well, That's actually more what I think about When I think about circularity."

Circular Economy

"Circularity in my opinion has multiple things, so circular also means that when you mean reuse the materials coming out, but also everything you put in new. So that cradle to cradle that you can take that out later and reuse it. It's a combination of everything we harvest now can be reused. It's on location or somewhere else, so You can also put it at the demolisher In the In the shelves has the same value for me, for me it has to. Really that to be applied to my project As long as it doesn't end up in the waste pile. I think that's where some of the circularity is. And indeed it. So, that's also the basis of repurposing which we steer it a lot towards is it demountable so actually that you can take everything the built-in package out again and then the building could get another function?"

"I think of the circular. Related to reusing raw materials, so in my experience the circular story is mainly. Well that you reuse raw materials. I think then the Maximum achievable would be, that you would not need any raw materials anymore. Then you, wouldn't have to tdig off clay or mine ore anywhere, or name it. Well, That would be utopia already, I think."

Interview results - Architects

“The one circular thing is mainly reuse, right? So That's Obviously something that you like to do anyway. And then come what you used to do with it, though. I see that as circular and the other is the natural also of can you add the material that is new? Can you reuse those later as well, right? That is then and that is where I think we are slightly less adapt from our restoration craft, but also so definitely interesting issue and what I then? Yes, but well, We have that about the project which is also very nice, But that is on the one hand I think of the use of materials that are released and the other is. As far as I'm concerned When it comes to circularity it's about that new materials. That those are as Natural as possible and also reusable again In the future."

Circular Economy

"In my view, it includes the realisation that you are part of a closed system on earth. That's where it starts. And André Kuipers knows how to tell it all so beautifully, but, But it's true. They are just part of that very thin Shell on the earth where, with plants and animals and all the minerals and all the yes present minerals. It will have to do? With each other. I find it a very fascinating As the architect to. Thinking about everything I find and how I relate to that and, how I deal with that, just like very simply how you build a hut as a child in a forest or so huh that? And then you also just deal with what you find, right there on the spot and you bend it to your will. That simple logic I still find very, very good.

Interview results - Clients

"Circular economy is not in economics, because you always have an economic side to it there. But circularity sees it In the society we live in which there is space for Everyone. And in that, we circular economy will also have to think about what is there, what can and? How are we doing that, now from my work I have an opportunity to do that, Because we have the real estate. And I fill it in through that. That real estate aspect."

"Nice container terms. I read up on your research question too. And I always have to think, circular I yes, look it, you must try to reuse as much as possible instead of using new things as far as possible. That it does top of mind, but He is also I think broader that we If you look at the website .We give space to People and that means we also give space to our organisation, because they are People. We try to give to think about that and that's little things and that's not done here either. Not very well instigated of, hey, let's see if we're doing the right things, so electric cars is Maybe one, But it can also literally be that we practice sustainability with each other by saying, we're going to do sports every week, we here with each other and then we really do every week. Those are very small things to indicate that it is also important besides the relaxation that it brings, that it is also sustainability."

"When you think about circular economy as I do, it's a kind of opportunity map that you see coming along, weighing up each time. Do I stay in my old groove When it comes to, for example, the. Forms of my specifications When it comes to floors, walls, ceilings, roofs, but also much wider hear In civil engineering. Road's planting foundations, bridges. Do I stay in that old group, or do I feel challenged to look for Circular measures or circular materials. Which ultimately aim to reach a point on the Horizon as an organisation or as a society of we want to be CO2 neutral or we want to be energy neutral,"

Circular Economy

"The circular economy well the most obvious actually what comes to mind then I actually end up with material use and how you deal with it. Avoiding large waste streams and reusing materials perhaps. Either from the building itself or from another building that is being demolished. Or where harvested. It is Of course actually much broader than Just material use, It is also. Actually reusing the building giving it new function, but what I think also fits best from XXX's point of view is making it part of the Rotterdam fabric again. And making a place part of the city again. (...) Of the some special places in their city, revalue that reuse. And. yeah, I think that to me is the circular economy."

"The CO2 reduction. Just the Energy reduction is very much in there. Well, just because we all need to emit less co two, just briefly Summarised, there's circularity in that, there's biodiversity in that. So, what can we improve in on and around our building? There's social responsibility in that, so that also says something about. How do we as a company deal in a sustainable way with our own people, with parties we work with? But that also applies, for example for tenants we try to get in our building, so that we try to get social functions in it very often and the last pillar for us is the, That is that we also want to pull the sector along. The monument sector so we are actually 1 big player though in that monument sector, so We have also said, yes things we learn and."

Interview results

Circular Economy

Interview results

Circular Economy

eco·no·my
The science that deals with people's efforts to achieve prosperity

Interview results

Circular Economy

eco·no·my
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Generating capital. From sustainability, economic, social and cultural aspects

Implementation

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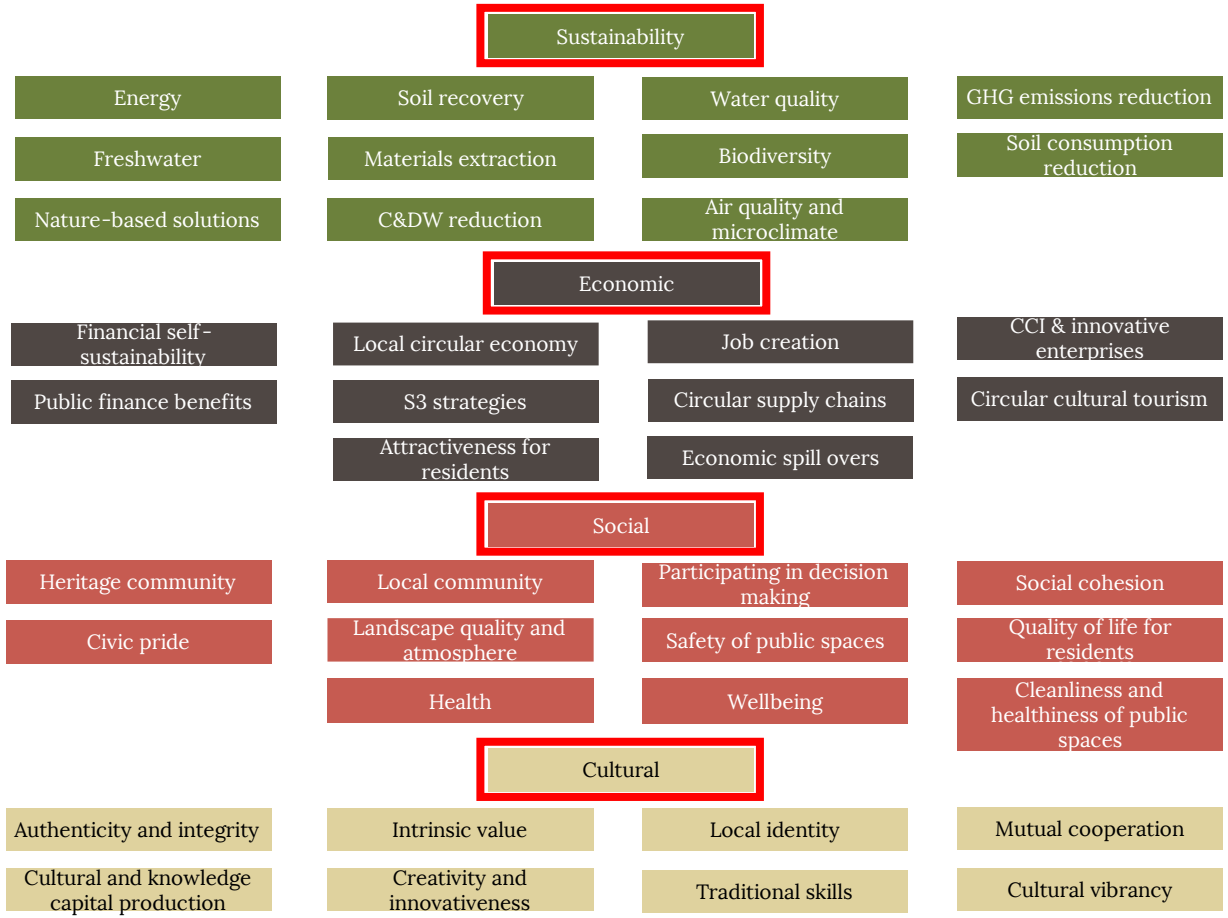
Implementation

- Coding
- Analysis
  - Code-document analysis



Coding tree (own illustration based on Bosone et al., 2021)

Interview results - implementation

	Contractor (5)	Architect (2)	Client (5)	Total
Cultural	9	3	4	16
Economic	4	0	4	8
Sustainability	38	12	11	61
Social	9	0	13	22
Total	60	15	32	107

Interview results - implementation

	Contractor (5)	Architect (2)	Client (5)	Total
Cultural	1,8	1,5	0,8	4,1
Economic	0,8	0	0,8	1,6
Sustainability	7,6	6	2,2	15,8
Social	1,8	0	6,5	8,3
Total	12	7,6	16	35,6

Interview results - implementation

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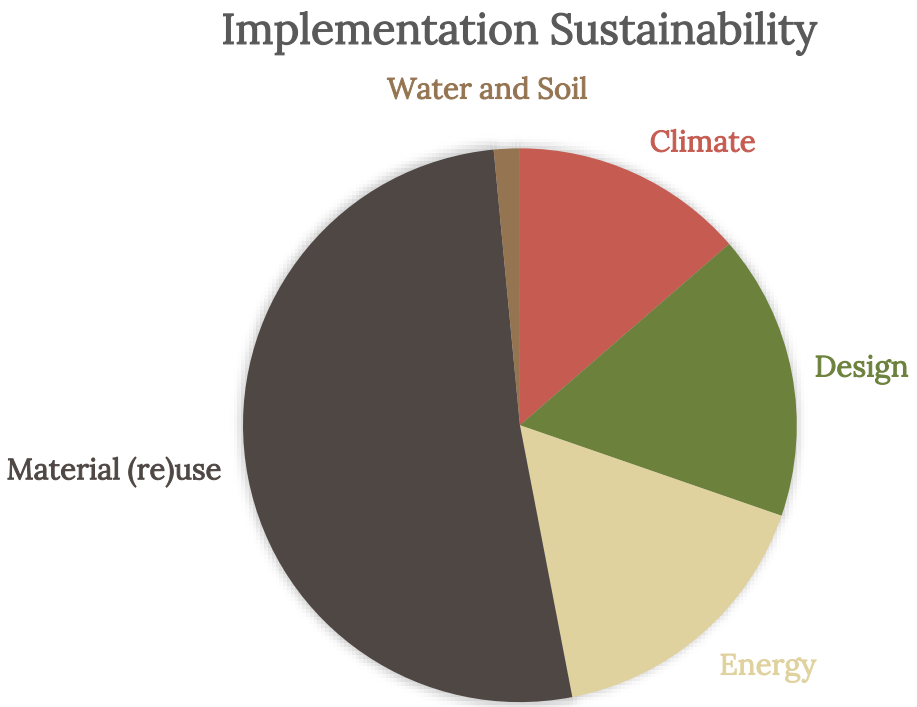
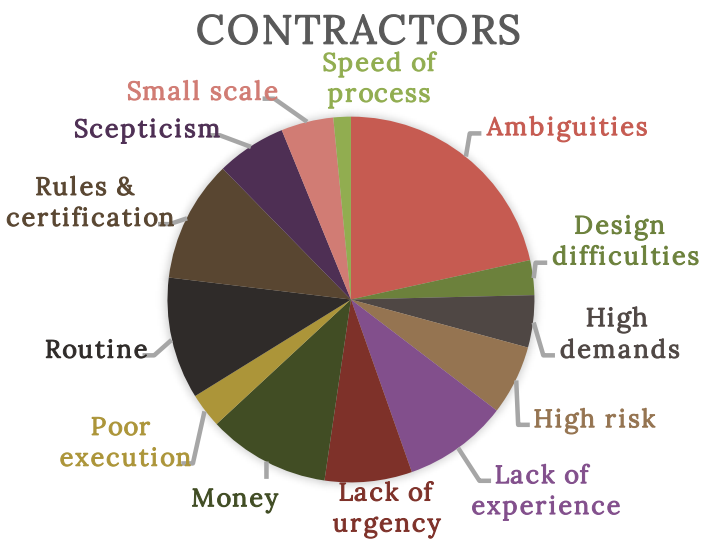
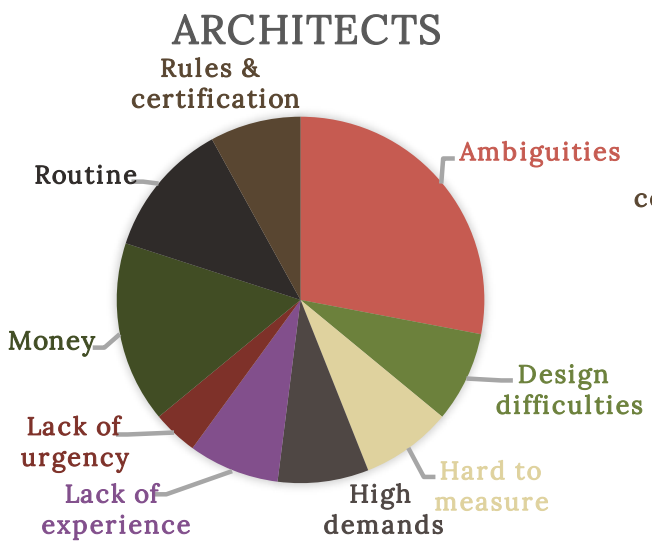
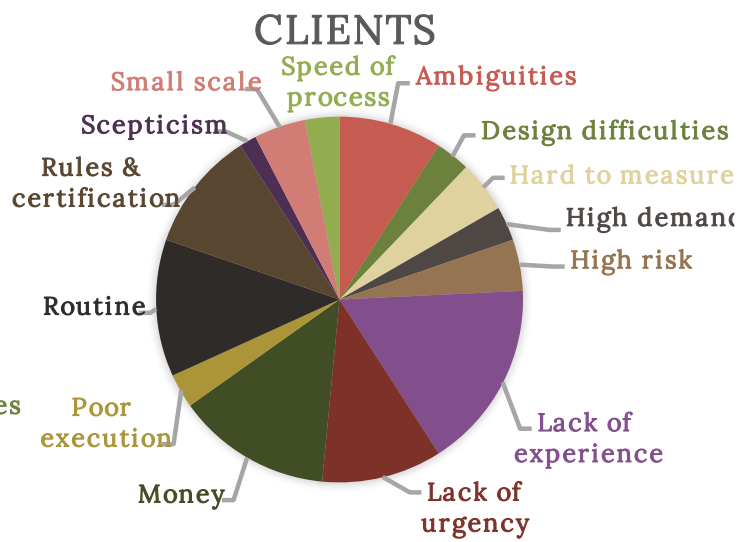


Barriers

Interview results – Barriers







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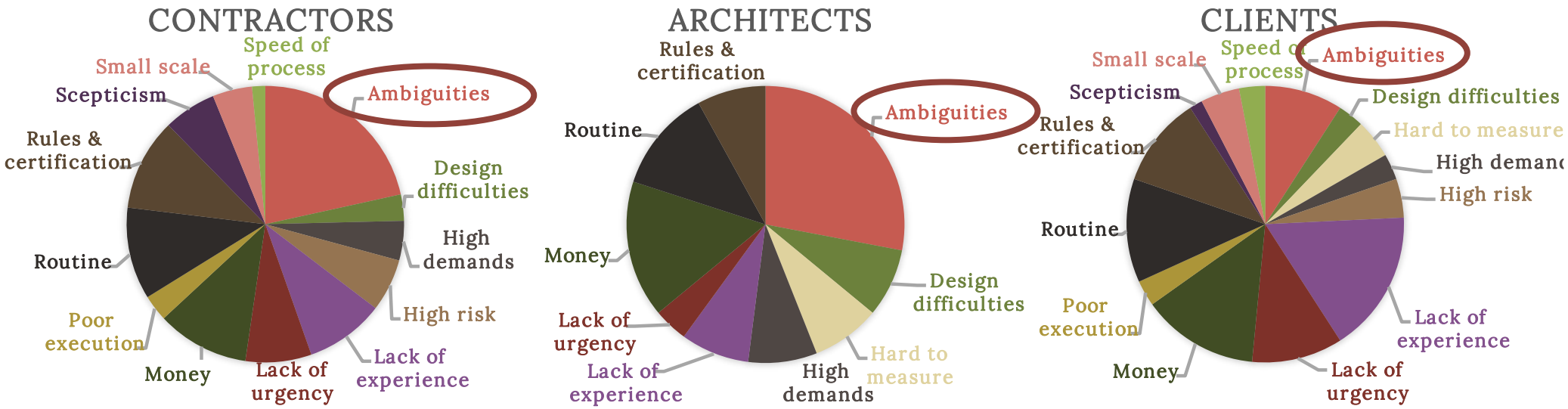

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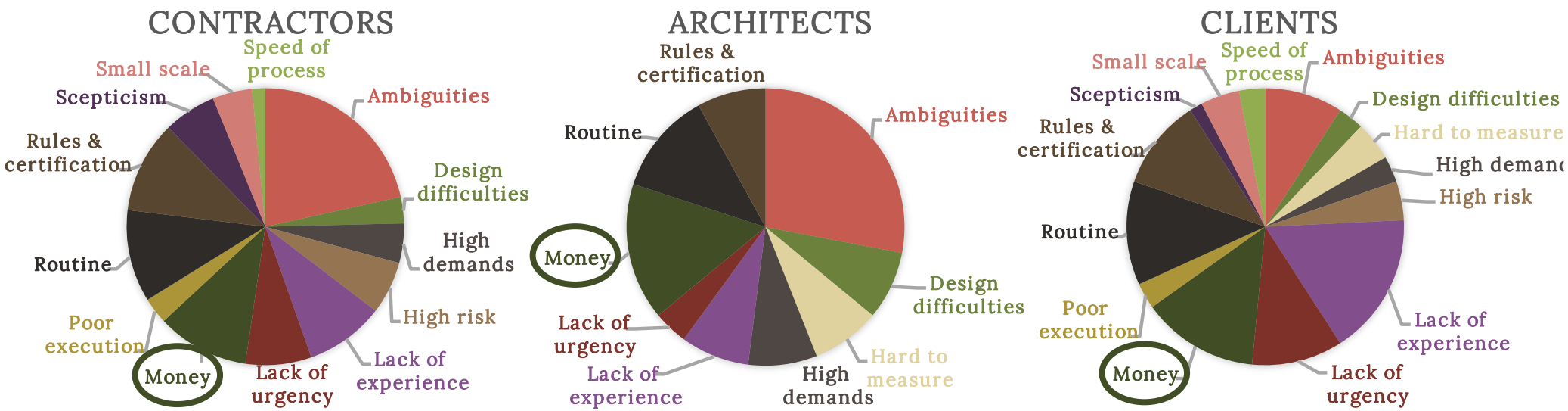

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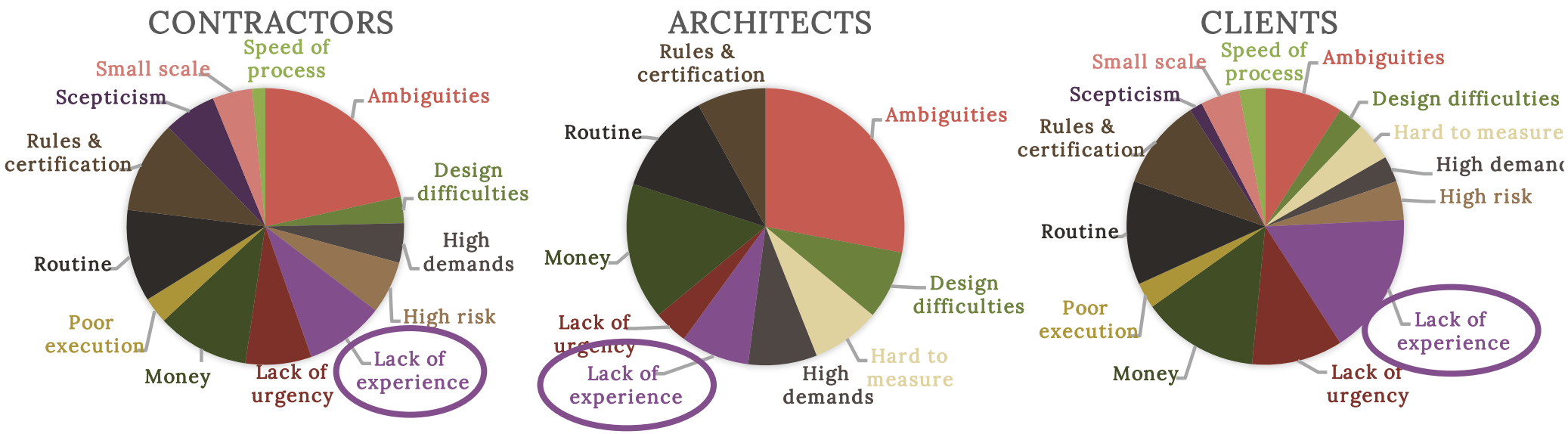

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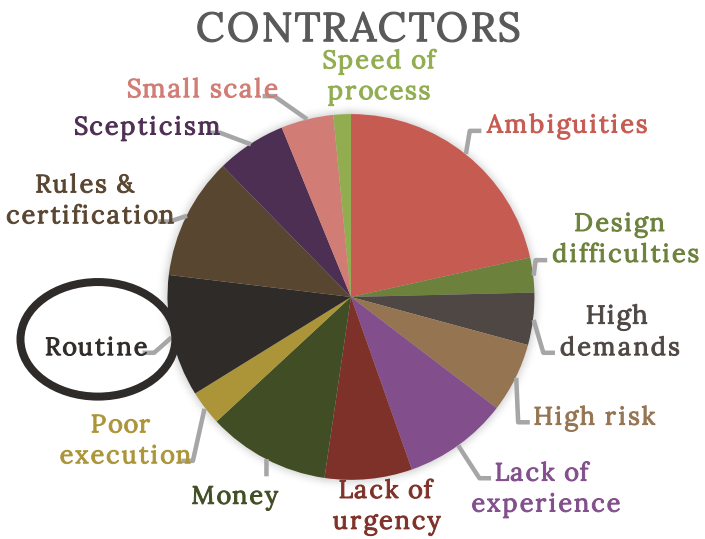

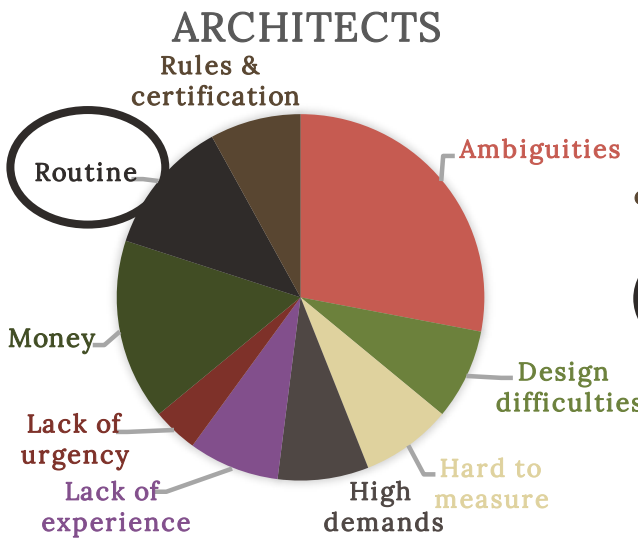

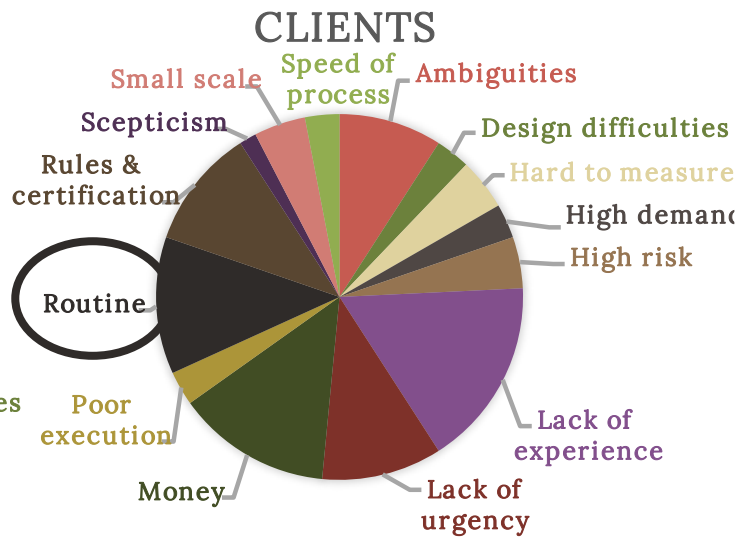

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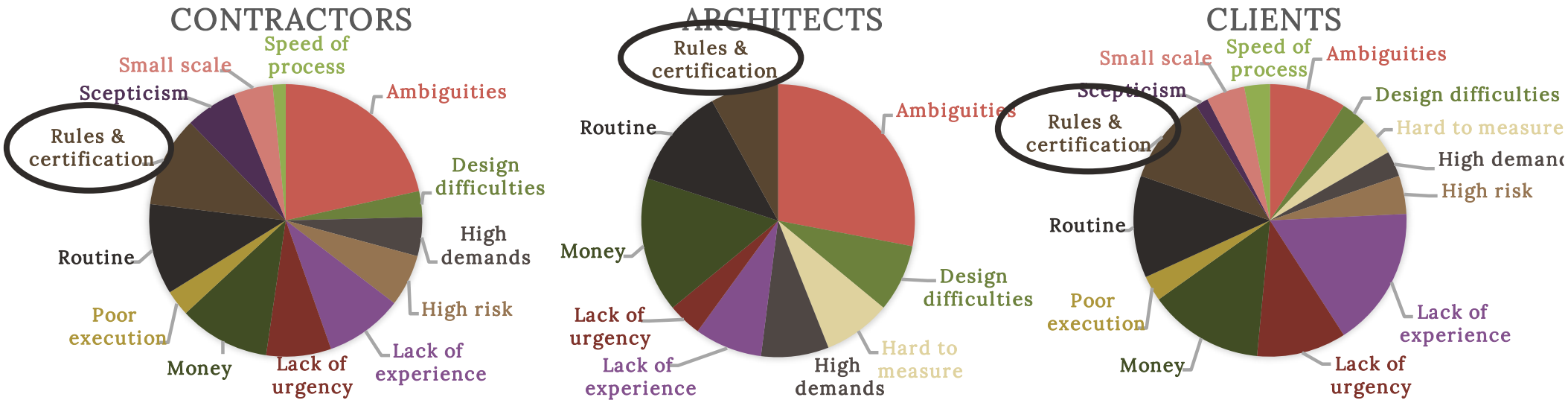
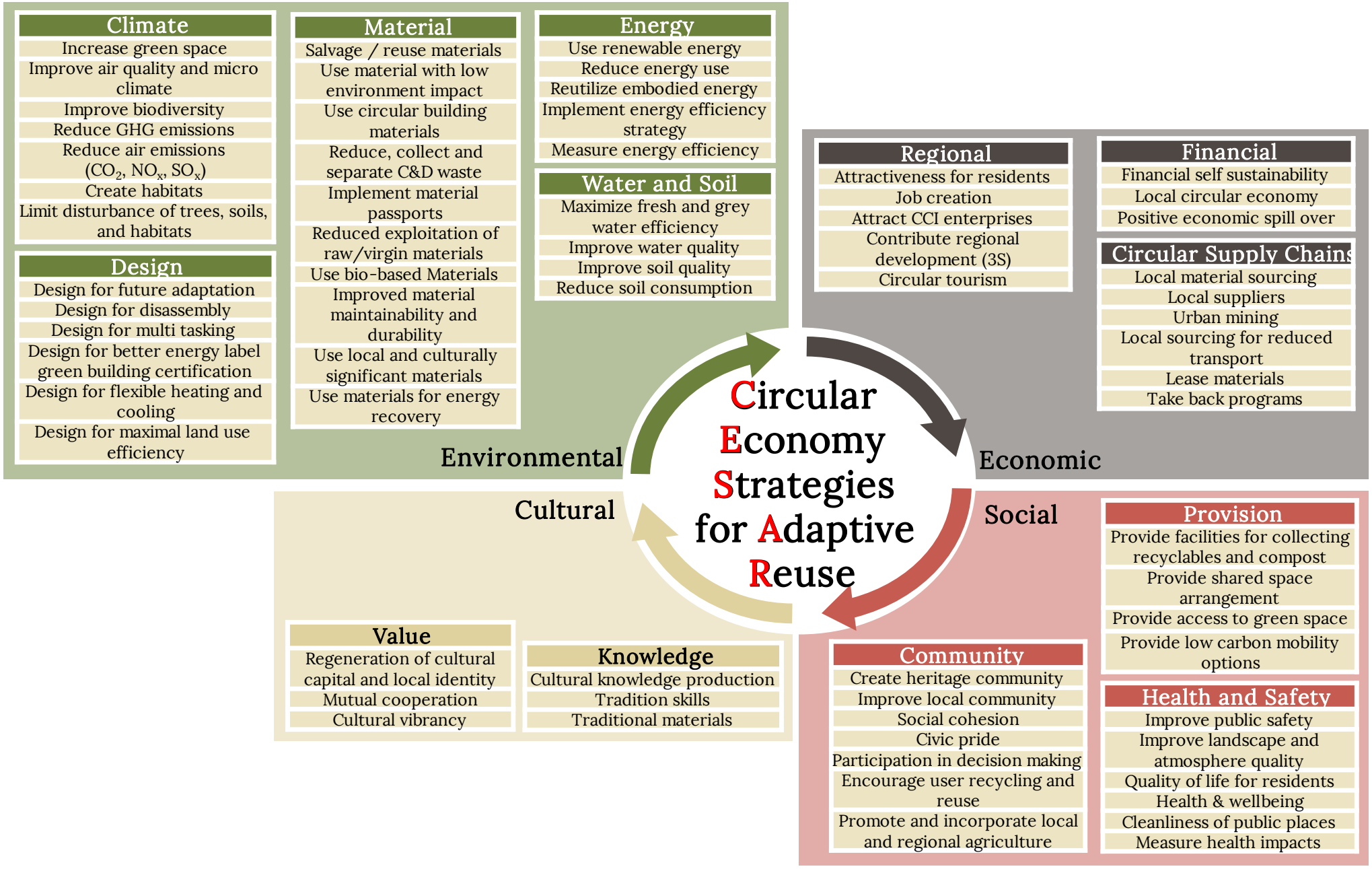


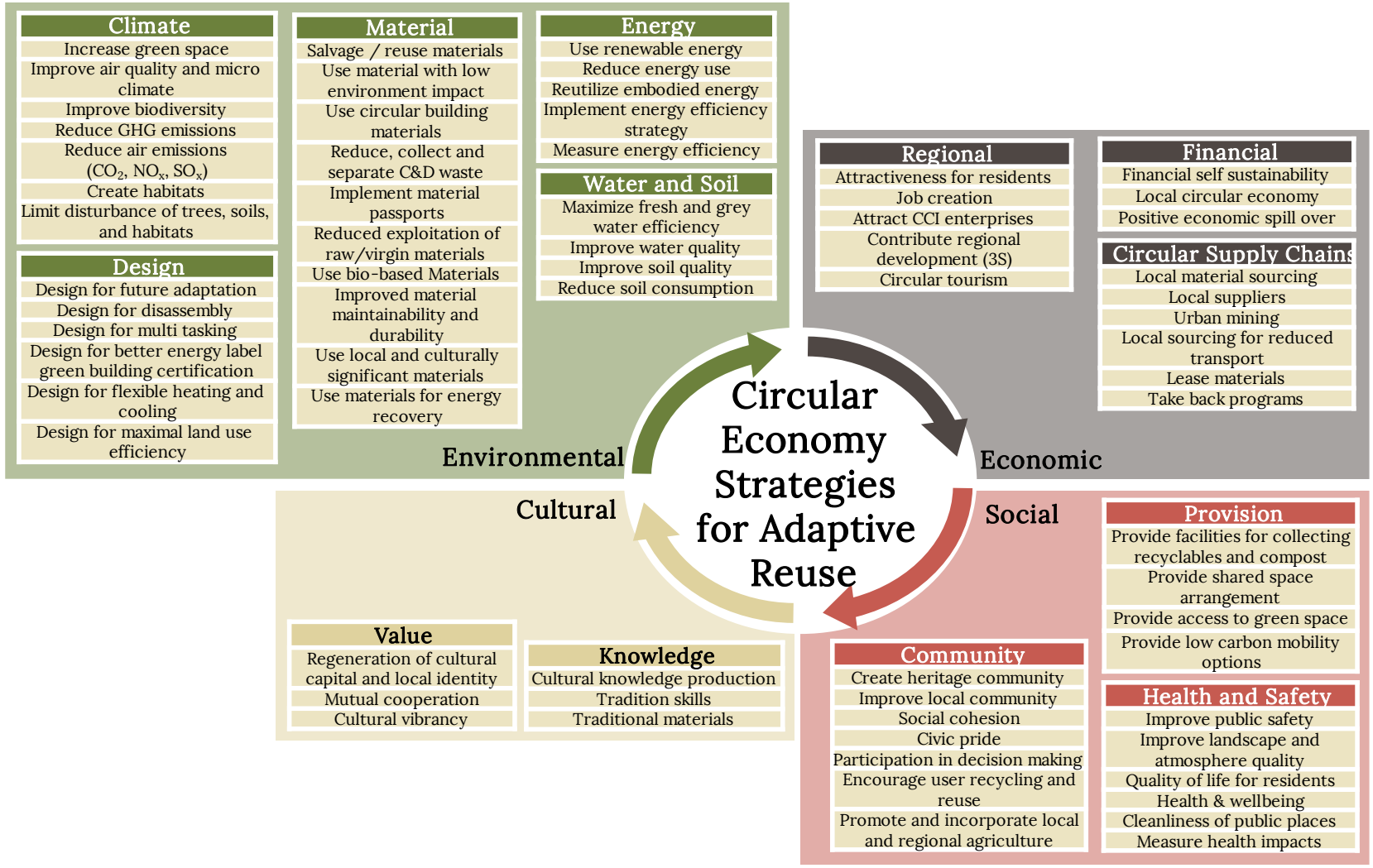
Case study conclusions

- Definitions
- Implementation
- Barriers



Case Study Research

CESAR-model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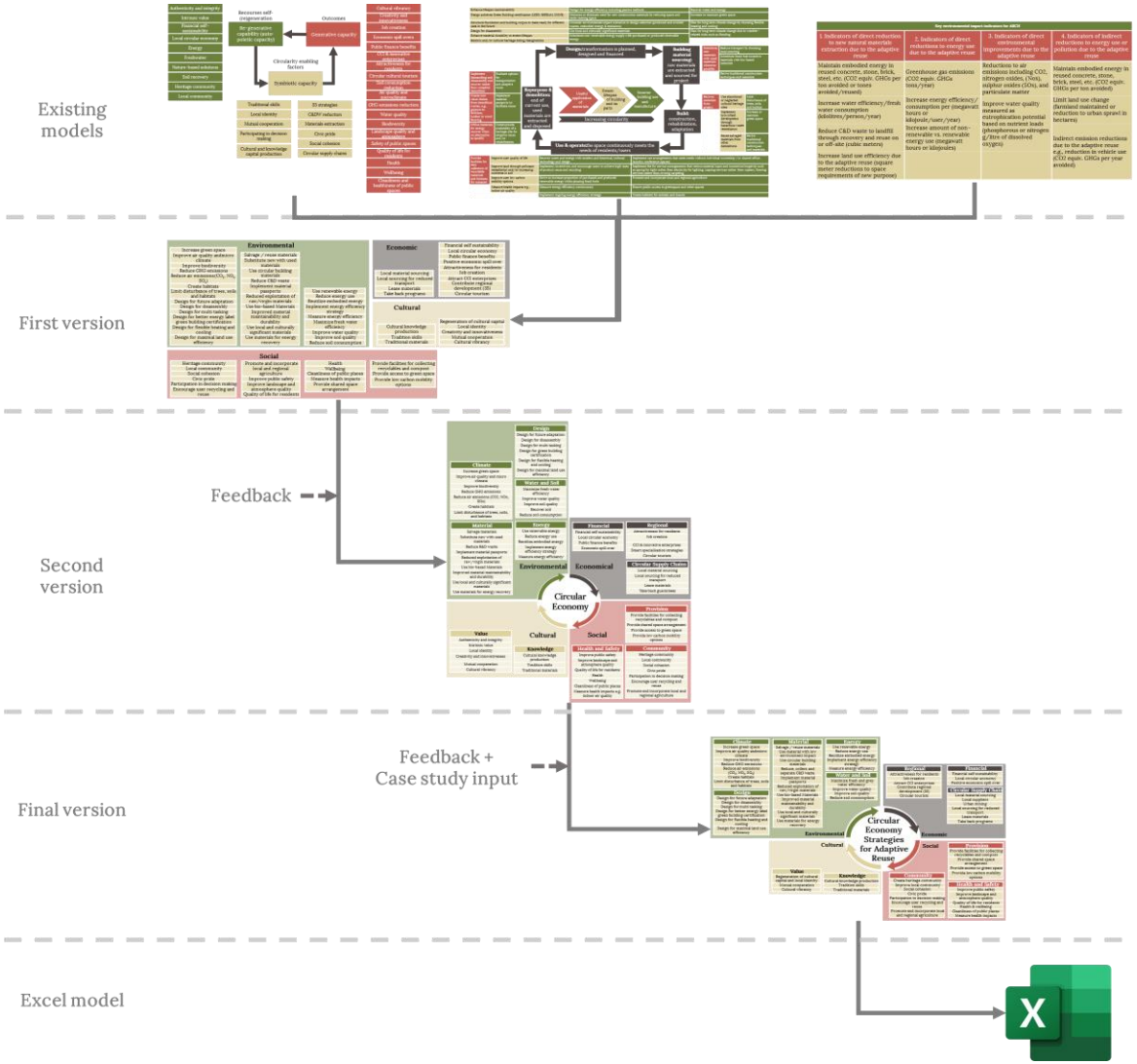
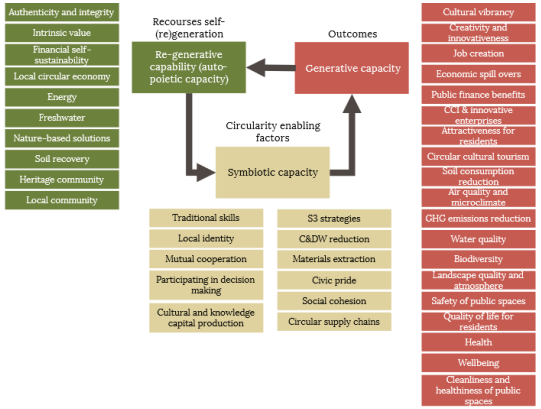
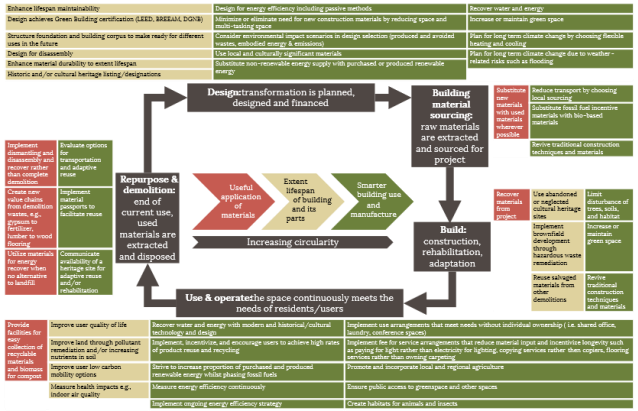
CESAR-model


Existing models
First version
Feedback
Second version
Feedback + Case study input
Final version
Excel model
Circular Economy
Circular Economy Strategies for Adaptive Reuse

CESAR-model

Existing models

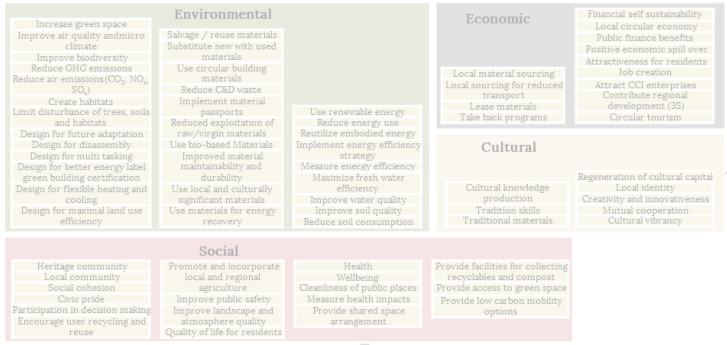




Key environmental impact indicators for ARCH

1. Indicators of direct reduction to new natural materials extraction due to the adaptive reuse	2. Indicators of direct reductions to energy use due to the adaptive reuse	3. Indicators of direct environmental improvements due to the adaptive reuse	4. Indicators of indirect reductions to energy use or pollution due to the adaptive reuse
Maintain embodied energy in reused concrete, stone, brick, steel, etc. (CO_2 equiv. GHGs per ton avoided or tones avoided/reused)	Greenhouse gas emissions (CO_2 equiv. GHGs tons/year)	Reductions to air emissions including CO_2, nitrogen oxides, (Nox), sulphur oxides (SOx), and particulate matter	Maintain embodied energy in reused concrete, stone, brick, steel, etc. (CO_2 equiv. GHGs per ton avoided)
Increase water efficiency/fresh water consumption (kilolitres/person/year)	Increase energy efficiency/ consumption per (megawatt hours or kilojoule/user/year)	Improve water quality measured as eutrophication potential based on nutrient loads (phosphorous or nitrogen g/litre of dissolved oxygen)	Limit land use change (farmland maintained or reduction to urban sprawl in hectares)
Reduce C&D waste to landfill through recovery and reuse on or off-site (cubic meters)	Increase amount of non-renewable vs. renewable energy use (megawatt hours or kilojoules)		Indirect emission reductions due to the adaptive reuse e.g., reduction in vehicle use (CO_2 equiv. GHGs per year avoided)
Increase land use efficiency due to the adaptive reuse (square meter reductions to space requirements of new purpose)			

First version



Case Study Research

CESAR-model

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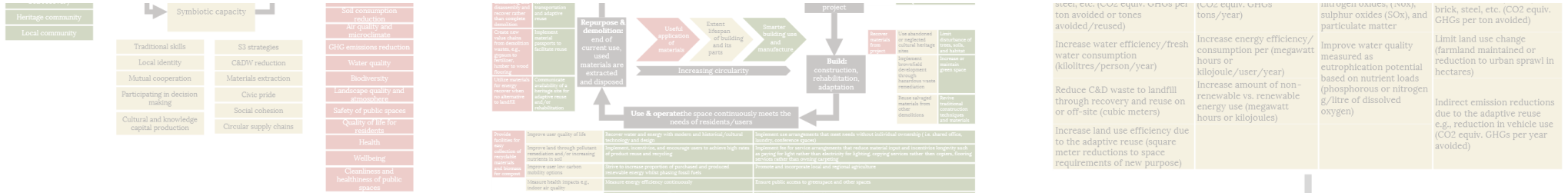

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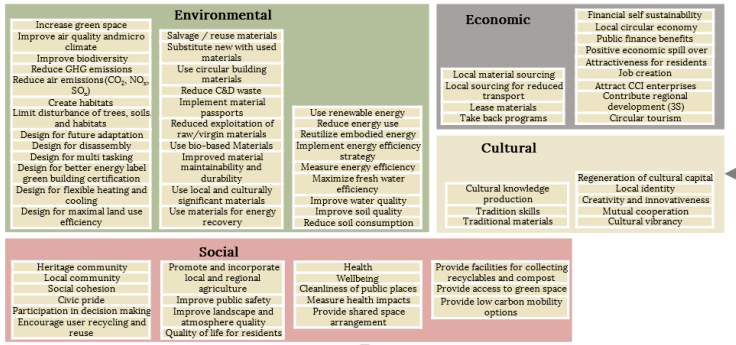

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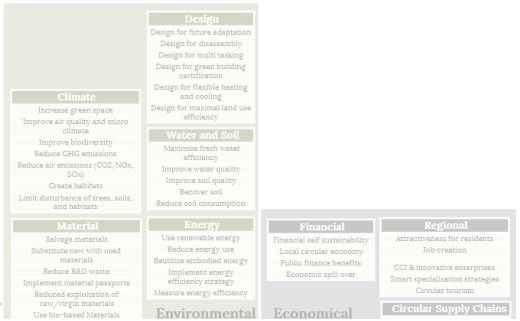
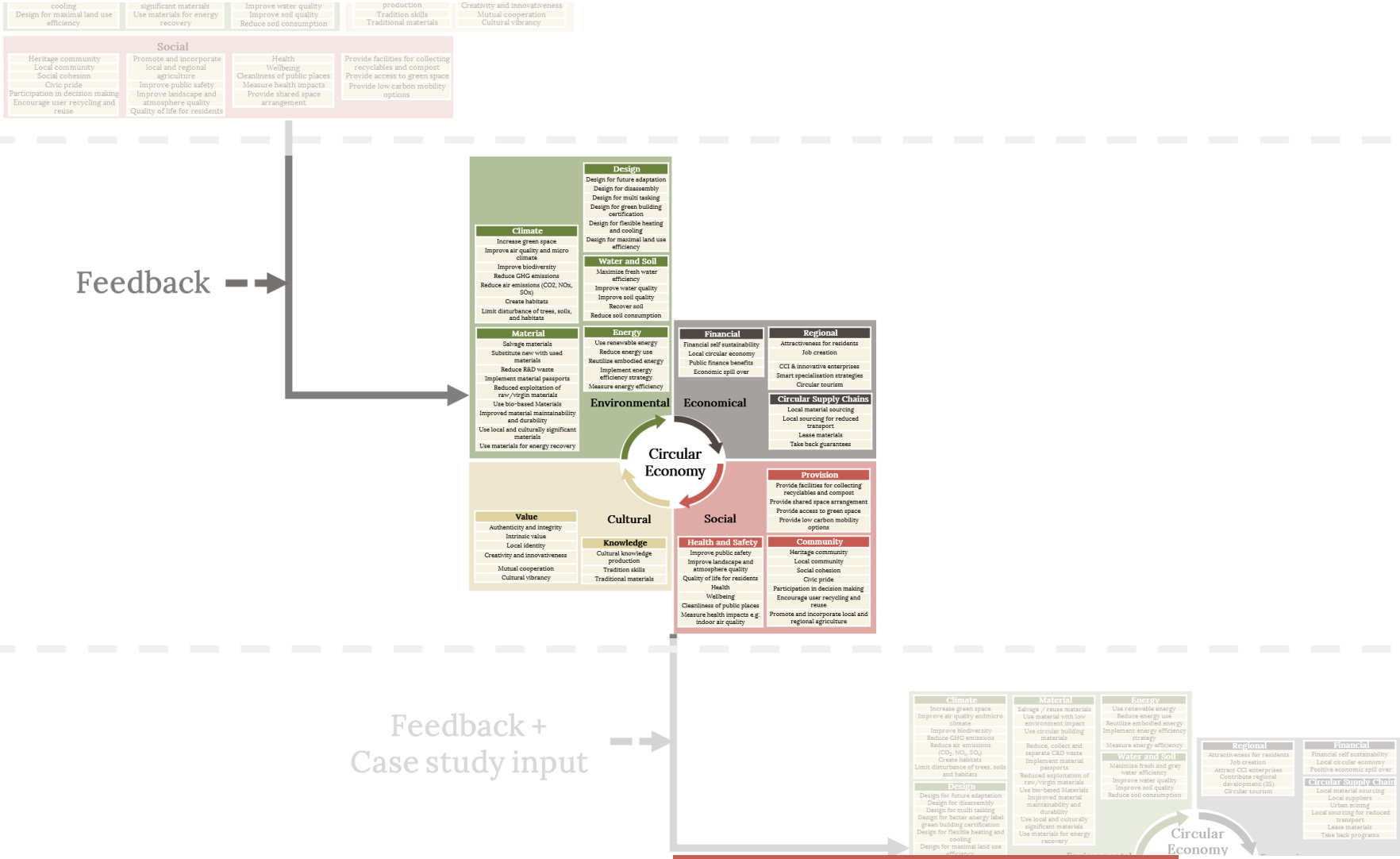


Second

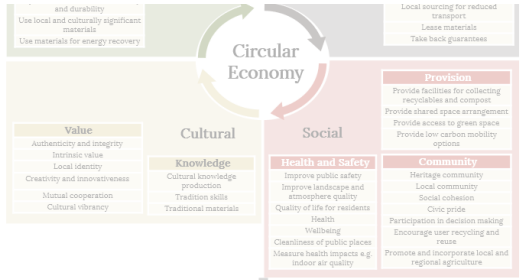
CESAR-model



Case Study Research

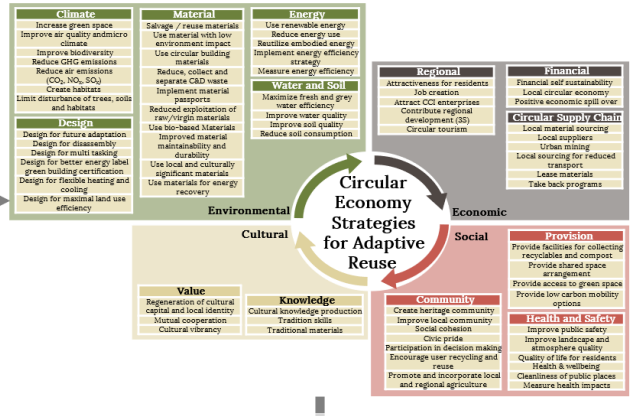
CESAR-model

version



Feedback +
Case study input

Final version



Excel model

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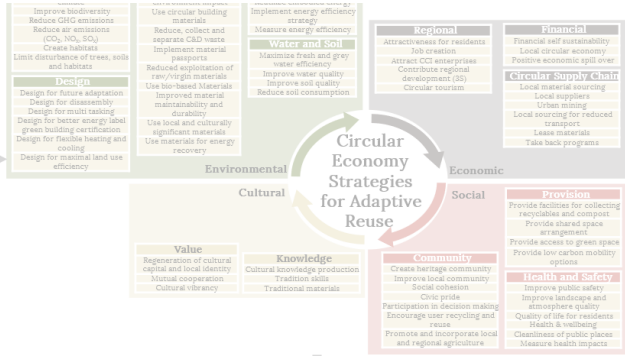

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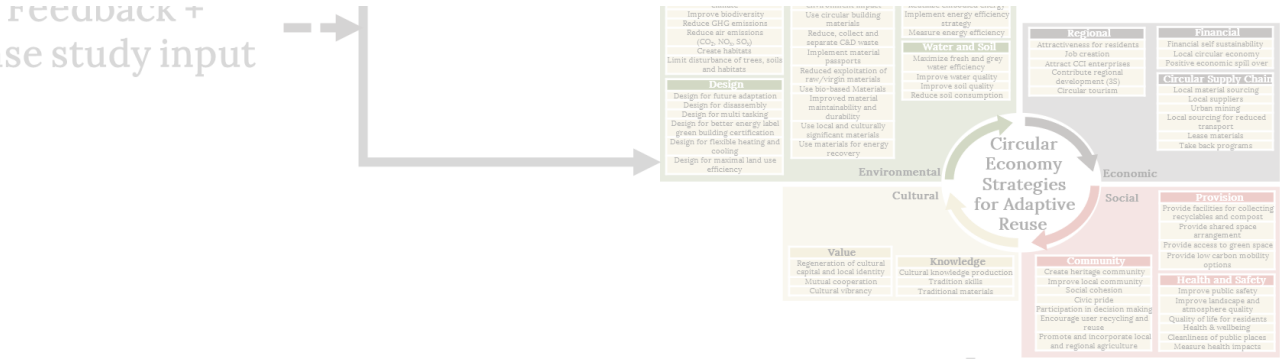


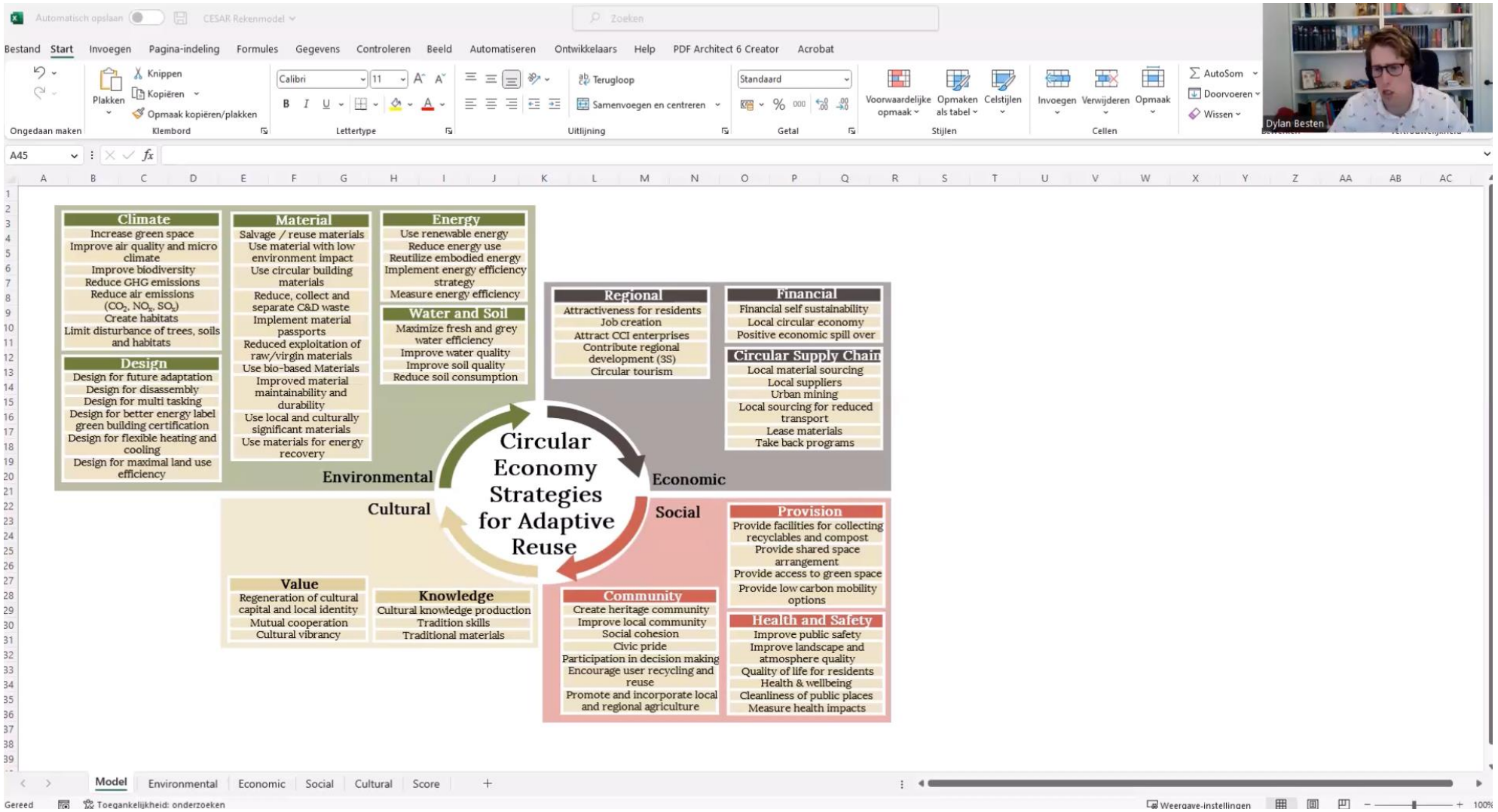
Version 1 → Version 2 → Version 3 → Version 4

Testing + feedback

Testing + case study feedback

Testing + focus group feedback

CESAR-model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Dylan Besten
Model
Environmental
Economic
Social
Cultural
Score

Provisional advice

- Clients
  - Circular tender
- Architects
  - Gain experience
  - Collaborate with contractors
- Contractors
  - Early involvement
  - Share information

Sub-question

SQ 1. How are circularity, adaptive reuse, and heritage defined within the context of the built environment?

SQ 2. What circular economy strategy assessment models exist for adaptive reuse projects of heritage buildings?

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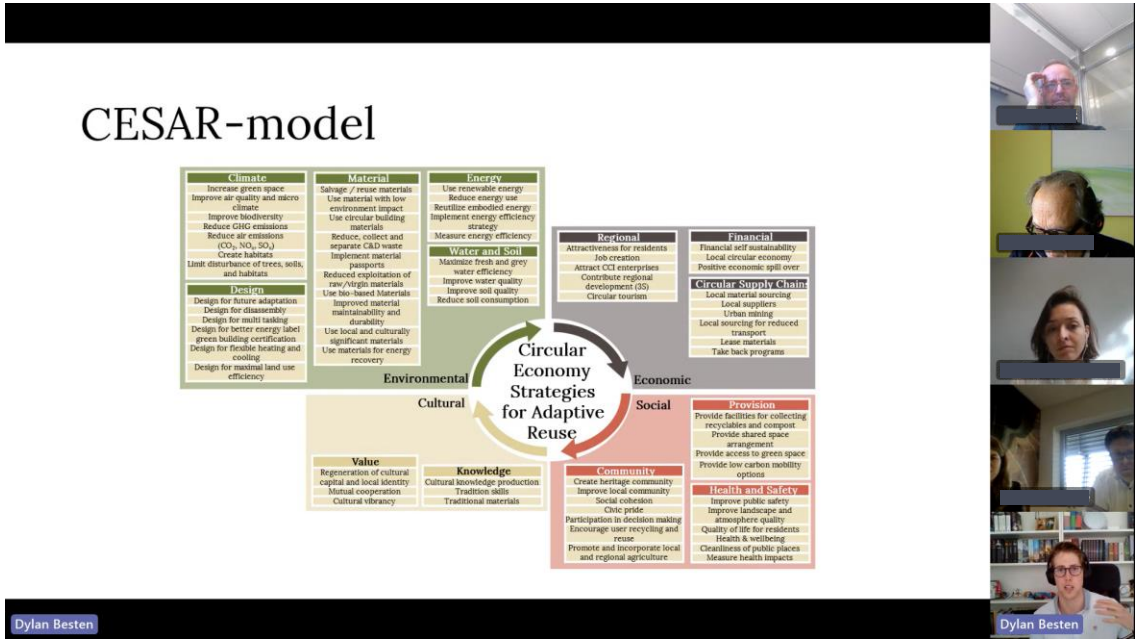
Focus Group


Dylan Besten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Dylan Besten
Dylan Besten

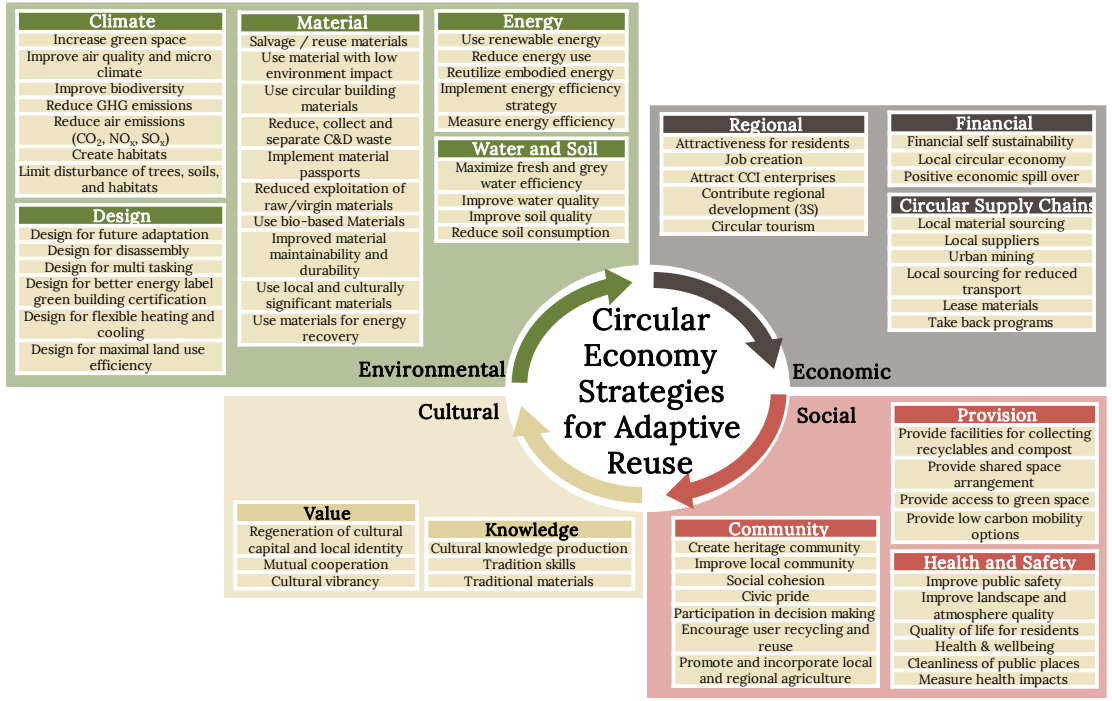
Focus Group - results

- Provisional advice
- CESAR model

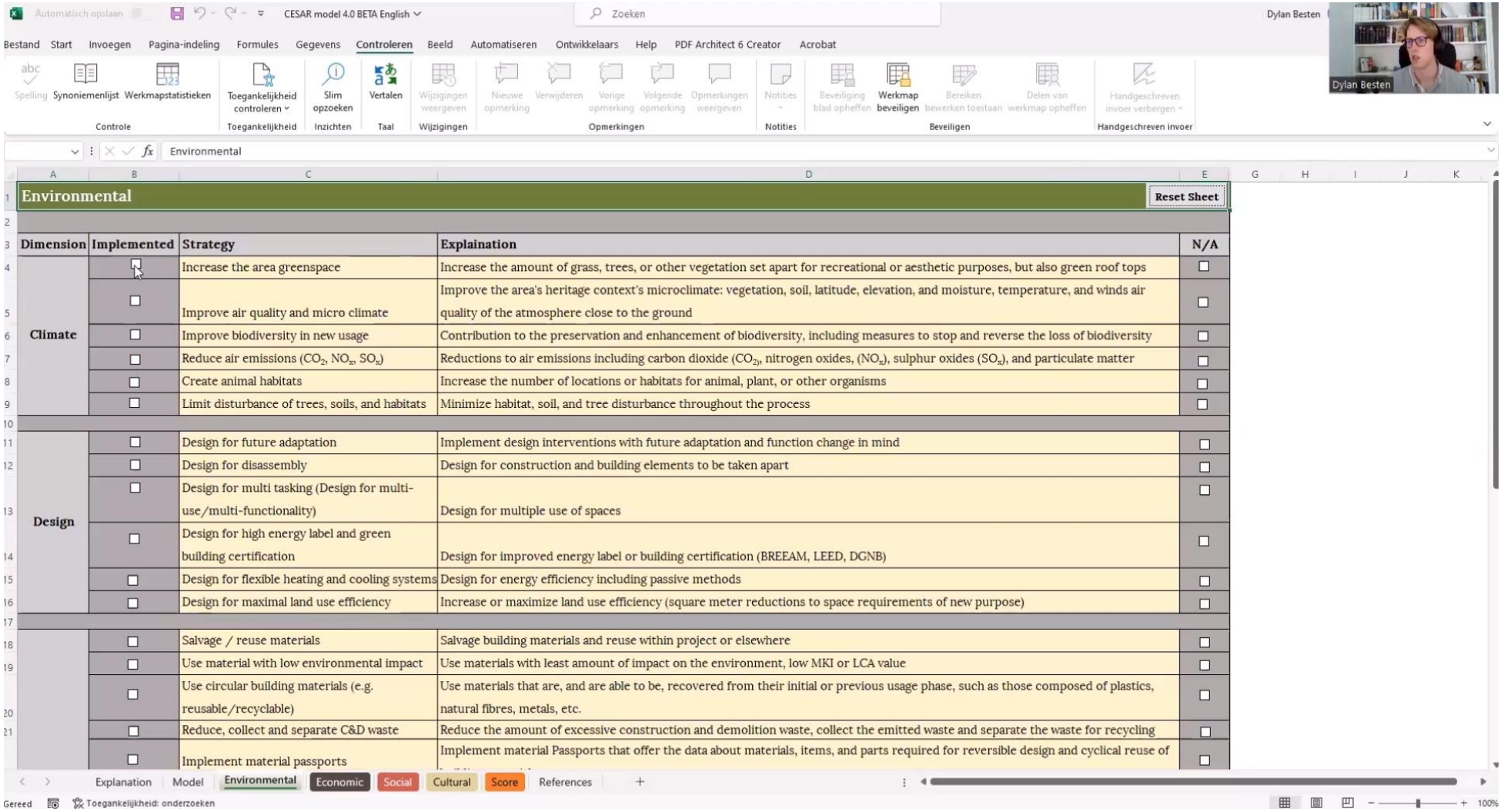
Cultural Heritage Agency of the Netherlands
Ministry of Education, Culture and Science

Focus Group - results

- Provisional advice
- CESAR model



Focus Group - results



Dimension	Implemented	Strategy	Explaination	N/A
Climate	☐	Increase the area greenspace	Increase the amount of grass, trees, or other vegetation set apart for recreational or aesthetic purposes, but also green roof tops	☐
	☐	Improve air quality and micro climate	Improve the area's heritage context's microclimate: vegetation, soil, latitude, elevation, and moisture, temperature, and winds air quality of the atmosphere close to the ground	☐
	☐	Improve biodiversity in new usage	Contribution to the preservation and enhancement of biodiversity, including measures to stop and reverse the loss of biodiversity	☐
	☐	Reduce air emissions (CO_2, NO_x, SO_x)	Reductions to air emissions including carbon dioxide (CO_2), nitrogen oxides, (NO_x), sulphur oxides (SO_x), and particulate matter	☐
	☐	Create animal habitats	Increase the number of locations or habitats for animal, plant, or other organisms	☐
	☐	Limit disturbance of trees, soils, and habitats	Minimize habitat, soil, and tree disturbance throughout the process	☐
Design	☐	Design for future adaptation	Implement design interventions with future adaptation and function change in mind	☐
	☐	Design for disassembly	Design for construction and building elements to be taken apart	☐
	☐	Design for multi tasking (Design for multi-use/multi-functionality)	Design for multiple use of spaces	☐
	☐	Design for high energy label and green building certification	Design for improved energy label or building certification (BREEAM, LEED, DGNB)	☐
	☐	Design for flexible heating and cooling systems	Design for energy efficiency including passive methods	☐
	☐	Design for maximal land use efficiency	Increase or maximize land use efficiency (square meter reductions to space requirements of new purpose)	☐
	☐	Salvage / reuse materials	Salvage building materials and reuse within project or elsewhere	☐
	☐	Use material with low environmental impact	Use materials with least amount of impact on the environment, low MKI or LCA value	☐
	☐	Use circular building materials (e.g. reusable/recyclable)	Use materials that are, and are able to be, recovered from their initial or previous usage phase, such as those composed of plastics, natural fibres, metals, etc.	☐
	☐	Reduce, collect and separate C&D waste	Reduce the amount of excessive construction and demolition waste, collect the emitted waste and separate the waste for recycling	☐
	☐	Implement material passports	Implement material Passports that offer the data about materials, items, and parts required for reversible design and cyclical reuse of	☐

Conclusion

What **circular economy strategies** are currently implemented in the **adaptive reuse of heritage buildings** and how can the **remaining barriers** be **mitigated** in order to move towards the **circular economy?**

Discussion

- Limitations
- Recommendations for further research

Discussion

- Limitations
  - Research scope
  - Research time
  - Participants
  - Methodology
- Recommendations for further research

Dankuwel

Reflection

- Relevance
- Methodology
- Personal Reflection