CIRCULAR MODELS LEVERAGING INVESTMENTS IN CULTURAL HERITAGE ADAPTIVE REUSE

The contribution of cultural heritage to *circular* city-region development

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This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 776758

The contribution of cultural heritage to *circular* city-region development

- The concept of **circular city** defines a city/territory in which the **circular economy (CE) model** of sustainable production and consumption is applied, “closing the loops” of urban metabolisms in terms of flows of materials, water, energy and wastes.
- **Circular cities and regions** are those in which **no wastes and other negative environmental externalities are generated**, while **productivity** is enhanced through wastes reuse, reduction of raw materials extraction, repair, refurbishment, etc.
- A **circular territorial system** is that in which **urban metabolisms are “closed”**, enabling economic growth decoupled from resources consumption.

The contribution of cultural heritage to *circular* city-region development

- This enhanced **‘productivity’** should be seen as **multidimensional**, with relevant **impacts on human and ecosystems health**, and **longer-term economic growth** (more independent from resources availability and prices volatility).

Circular models Leveraging Investments
in Cultural heritage adaptive reuse

The contribution of cultural heritage to *circular* city-region development

- **Cultural heritage (CH)** regeneration and **adaptive reuse** can play a key role for the achievement of a circular city-region. It **reduces soil consumption by re-generating existing buildings and sites with new functions**, and valorises the embedded energy of constructions.
- CH can have positive impacts on **local economies**, **jobs** and **enhancing attractiveness of cities for residents, visitors and enterprises**.
- It also generates **positive social impacts** enhancing **quality of places**, and thus **quality of life and wellbeing / health**, enhancing **place attachment and care** through its symbolic values, it contributes to local **communities' bonds and civic attitude**.

Aims of this work (ongoing research)

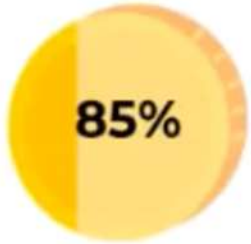
- This work develops a methodology for **integrated urban metabolisms assessment** that takes into account **flows of materials, water, energy and wastes**, but also **social, cultural and economic flows** to assess the contribution of cultural heritage regeneration and adaptive reuse to the realization of circular cities and regions.
- A **methodological proposal** based on integration of **multicriteria analysis** and **urban metabolisms assessment** to assess the **contribution of cultural heritage adaptive reuse for circular urban-regional development** and to implement the **human scale of local development** (see the New Urban Agenda and New Urbanism Charter).

Urban Metabolism assessment methodologies

- Negative impacts of the **current (linear) economic model** determined on one side **climate change effects**, and on the other side **social inequalities**.
- This obliges to identify a new economic model that is the economic model of nature: it is defined as the “circular economy”.
- In this general perspective, it is necessary to research **new evaluation methods** to manage the transformations of the natural and built environment.

IN NUMBERS, CITIES...

...account for



of global GDP generation

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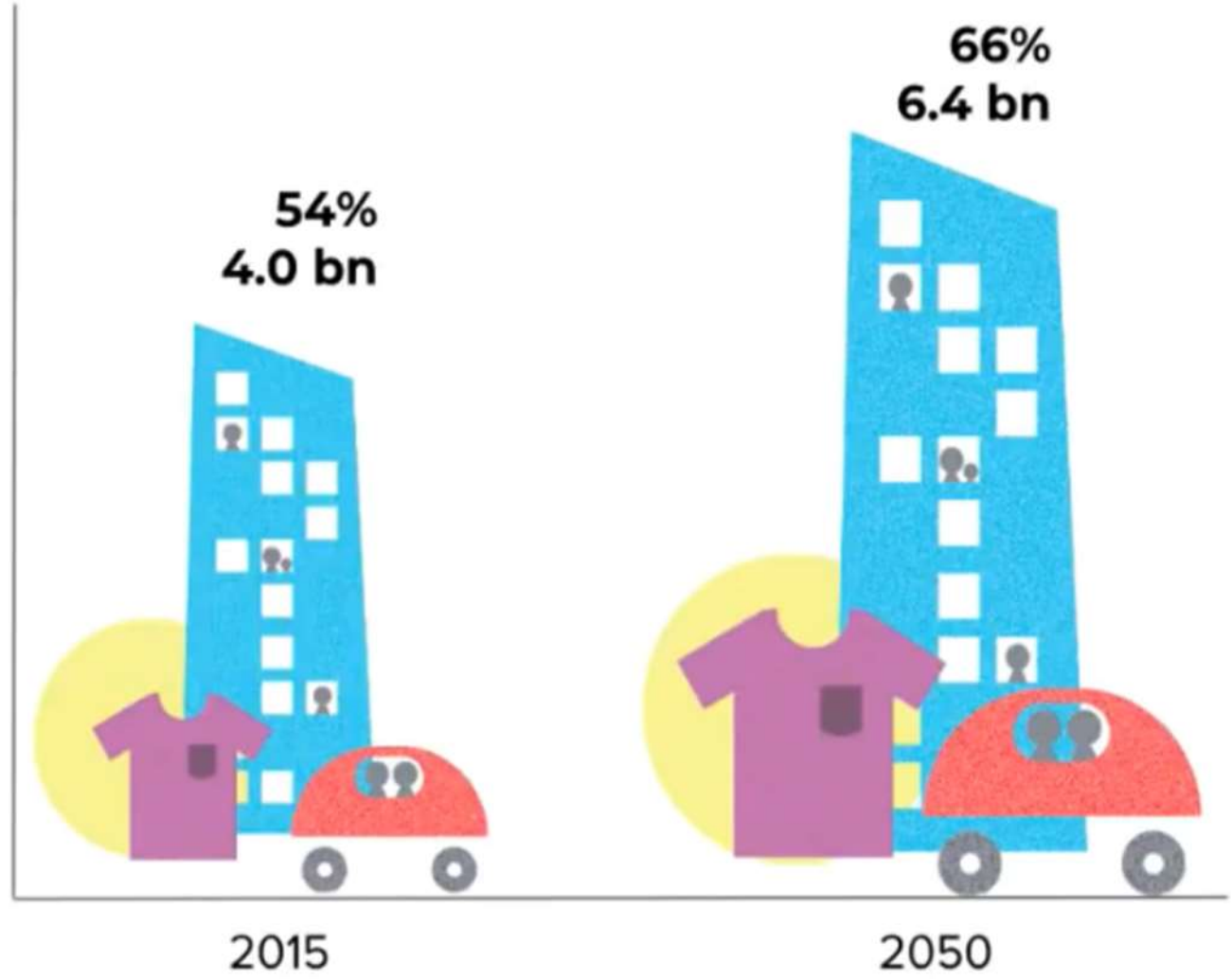

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Urban Metabolism assessment methodologies

- A way to assess the environmental performance of the city / region is the **Urban Metabolism assessment**, which includes different methods that have been explored since the 60s in the scientific literature.

Urban Metabolism assessment methodologies

- **Urban Metabolism (UM)** is a concept developed since the 60s to summarize the ideas of modelling and assessing the environmental effects of urban activities (Wolman, 1965). In 2007, Kennerdy et al. (2007) defined the UM concept as: "the sum total of the technical and socioeconomic processes that occur in cities, resulting in growth, production of energy and elimination of waste".
- **UM** serves as a model of a system that combines anthropic activities occurring in cities (e.g. transport, energy consumption) and their related urban infrastructure (e.g. roads, buildings) – also beyond the city limits, including the regional systems and eventually the environmental impact of cities at global level.

Urban Metabolism assessment methodologies

- Many studies have developed and tested UM methodologies at city, region and global scale. A recent review of the literature conducted by Beloin-Saint-Pierre et al. (2017) analysed 150 scientific studies on UM, exploring the evolution of the concept and the differences between the methodologies applied.

Urban Metabolism assessment methodologies

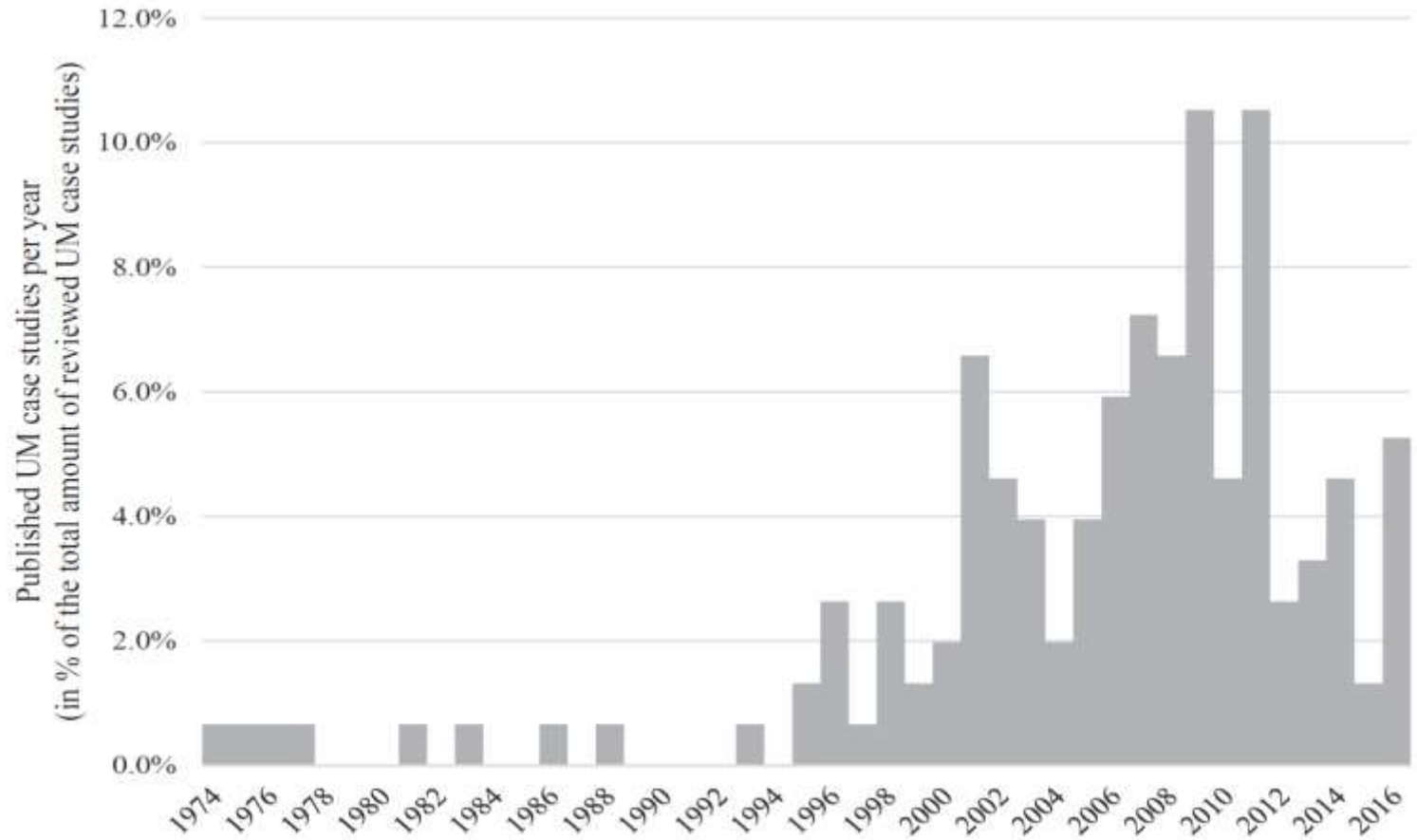


Fig. 1. Histogram of reviewed UM case studies that have been published since 1974.

Urban Metabolism assessment methodologies

The most commonly used methodologies for UM assessment can be referred to seven main typologies:

- 1. Flow analysis
- 2. Energy assessments
- 3. Footprints
- 4. Input/Output analysis
- 5. Network analysis
- 6. LCA Life-Cycle Assessment
- 7. Integrated (combination of previous methods)

Urban Metabolism assessment methodologies

In terms of output of the assessment methods, the urban systems can be analysed in terms of:

- **Self-sufficiency** (a concept that can be related to the **circular economy**), mostly through Environmental Network Analysis (ENA) method. It analyses the level of exchanges between different “nodes” (processes/components) of the urban system: higher interdependence between nodes makes the UM more self-sufficient;
- **Flows of substances** entering, moving and exiting the UM, using Input/Output from the Material Flow Analysis category of methods;
- **Environmental impact** of UM systems or their components – in this case, the flows between processes or components of a UM and their respective environmental interventions (e.g. resource extractions, emissions of pollutants) must be first defined, aggregated and then translated into potential impacts. With such modeling and analysis, the environmental performance of a UM is evaluated by comparing the impacts value across different development scenarios.

Source: Beloin-Saint-Pierre et al. (2017)

Urban Metabolism assessment methodologies

In terms of geographical scope, the UM is commonly assessed at three main scales:

- City
- City-region
- Global

In terms of temporal scope, the UM can be performed considering:

- Single year
- Time-series

The typical elements considered in a UM assessment are:

- Materials
- Energy
- Economics
- Processes

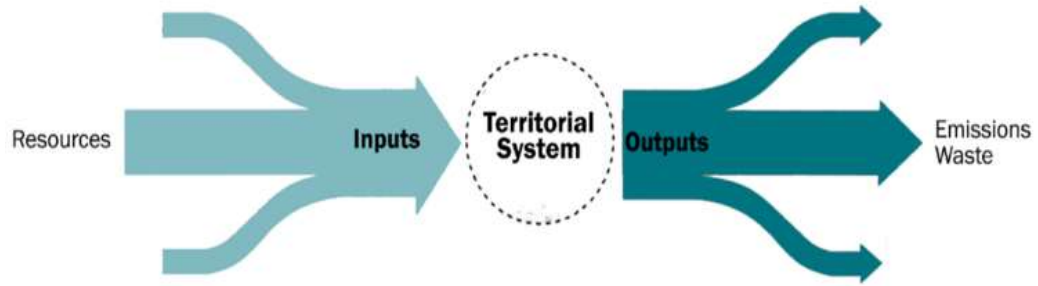
Urban Metabolism assessment methodologies

- Considering the above characteristics, a **Life-Cycle perspective** can be adopted to perform the **UM assessment**, considering the life-cycle of urban components, “from cradle to grave”: **extraction, production, use, end-of-life**.

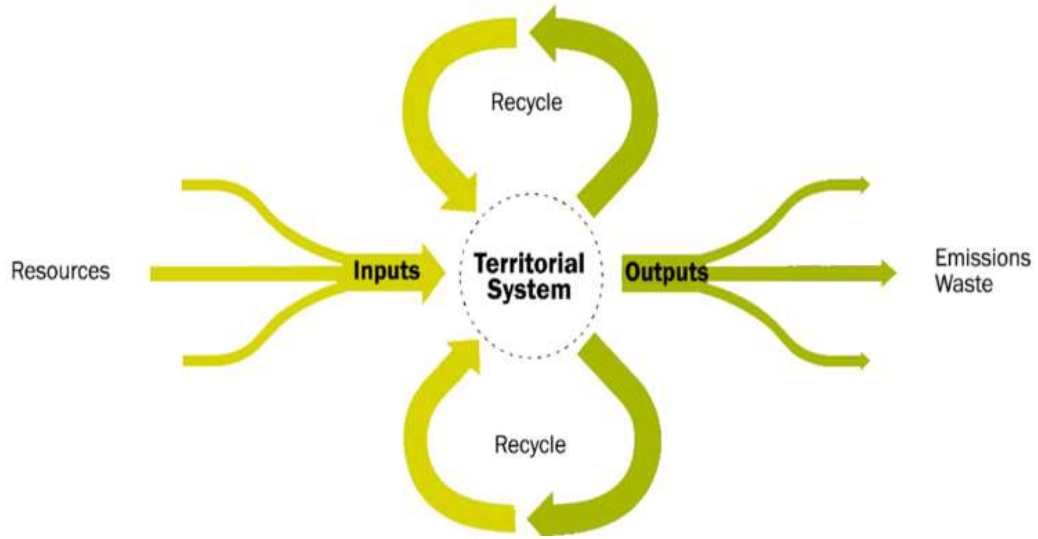
Urban Metabolism assessment methodologies

- This **urban metabolism** can be applied at the **urban scale**, but also at the **regional level**, as well as at the **neighborhood and "building" scale**. At the city-region system, as well as at the scale of a single building / site as an entrance point to realize the circular city.
- In the **circular economy** perspective of "**closed urban metabolisms**", the Life-Cycle is considered as a closed process going **"from cradle to cradle"** – meaning the elimination of the "end-of-life" stage as far as possible, re-employing materials and energy, as well as economic resources, for new production-consumption processes, eliminating GHG emissions and wastes of all types.

Urban Metabolism assessment methodologies



LINEAR METABOLISM



CIRCULAR METABOLISM

Assessing the contribution of cultural heritage adaptive reuse to Circular/Closed Urban Metabolism

The UM assessment framework proposed focuses on **the role of cultural heritage / landscape for the enhancement of overall productivity of the urban system** (expressed in terms of multidimensional **input-output** ratio), and particularly focuses on the **process of "adaptive reuse" as a contribution to 'closed' urban metabolisms**.

To perform an assessment of the level of "achievement" of a closed urban metabolism, the "objectives" and thresholds need to be set.

To this aim, three principles / objectives have been defined for the "ideal" cultural heritage adaptive reuse model:

- **Auto-poietic capacity**
- **Generative capacity**
- **Symbiotic capacity**

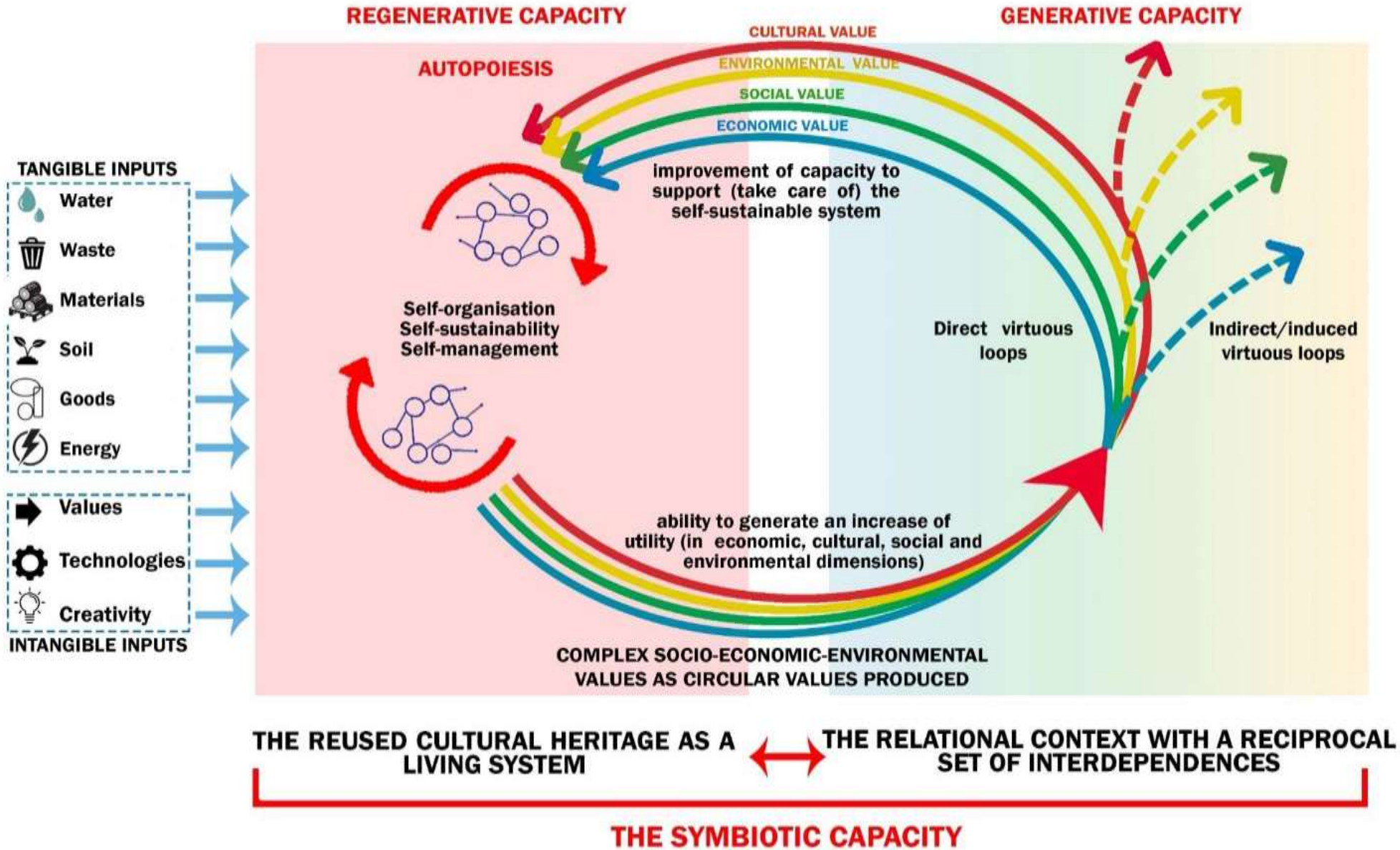
Assessing the contribution of cultural heritage adaptive reuse to Circular/Closed Urban Metabolism

- The **“auto-poietic” capacity** is the fundament of circular economy: it expresses the self-regenerative character of nature that is founded on **intrinsic ecosystemic values**. It is explicitated as the capacity of **self-generating the environmental resources** needed for its functioning, as well as the capacity of **self-regenerating economic-financial self-sustainability and also self-regenerating social-cultural values** over time.
- From this self-regenerative / autopoietic capacity stems the capacity of sustaining other components, and thus the **generative capacity** (the capacity of generating instrumental values).

Assessing the contribution of cultural heritage adaptive reuse to Circular/Closed Urban Metabolism

- The **“generative” capacity** is expressed as the capacity of the cultural heritage adaptive reuse to **generate new economic-financial and social resources** in the local context, considering thus the economic spillovers and social impacts generated through the adaptive reuse process. And also cultural impacts.
- The **“symbiotic” capacity** is expressed also in terms of **symbiotic exchanges with the context**. This concept can be better understood through a simple example: the same adaptive reuse project could have different performances if placed in different context.
- It guarantees the dynamic aspect of the above model. It includes also immaterial relationships between the site and the people (that perceive a sense of belonging, attachment, identity, etc) which determine the Heritage Community.

THE FUNCTIONAL REUSE: FROM COST TOWARDS INVESTMENT



THE REUSED CULTURAL HERITAGE AS A LIVING SYSTEM ⟷ THE RELATIONAL CONTEXT WITH A RECIPROCAL SET OF INTERDEPENDENCES

THE SYMBIOTIC CAPACITY

Assessing the contribution of cultural heritage adaptive reuse to Circular/Closed Urban Metabolism

- To develop the overall UM assessment model, the **inputs and outputs** need to be defined. In the case of cultural heritage, **“material” inputs** should be considered (construction materials, energy, water, soil), but also **“intangible” inputs** such as cultural values and other intangible values to be conserved and enhanced through the adaptive reuse process.
- The attractiveness of a site strictly depends on the above characteristics.

Assessing the contribution of cultural heritage adaptive reuse to Circular/Closed Urban Metabolism

- This theoretical “ideal” model becomes operational through the integration of **Urban Metabolism assessment** method based on **Life-Cycle Assessment (LCA) approach**, integrated by a **multi-criteria analysis** to consider **inputs and outputs**, as well as **impacts** of the cultural heritage adaptive reuse process in m**ultiple dimensions**.

The Horizon 2020 «CLIC» project (2017-2020)

- Starting from the Horizon 2020 CLIC project first results, this work aims to structure a **Circular Urban Metabolism assessment framework** that focuses on the **reuse of cultural heritage / landscape in cities and regions**, assessing the **contribution of cultural heritage / landscape "adaptive reuse" to the circular city-region model**, considering **multiple dimensions** in which this contribution is expressed, and **defining relevant criteria and indicators**.

Assessment of «circularity» performance of 126 adaptive reuse cases in Europe

- Best practices have been identified by building a **Structural Equation Model (SEM)** defined by a series of **Manifest Variables** (31 single "indicators" of circularity).
- These Manifest Variables have been grouped into seven **Latent Variables**, which represent latent "concepts" underlying the overall circularity performance.

Source: Horizon 2020 CLIC project - Deliverable 1.3 - Survey on best practices of cultural heritage adaptive reuse. Authors: Gravagnuolo A, Fusco Girard L, Vellecco I, Lauro N C. 2019. Section 3.2 Identification of Best Practices: a modelling-based approach.

Assessment of «circularity» performance of 126 adaptive reuse cases in Europe

The **Latent Variables (LV)** and their associated **Manifest Variables (MV)** are the following:

"Exogenous" Latent Variables (which impact on Endogenous Latent Variables):

- **Cultural value enhancement**
- **Management characteristics and self-sustainability**

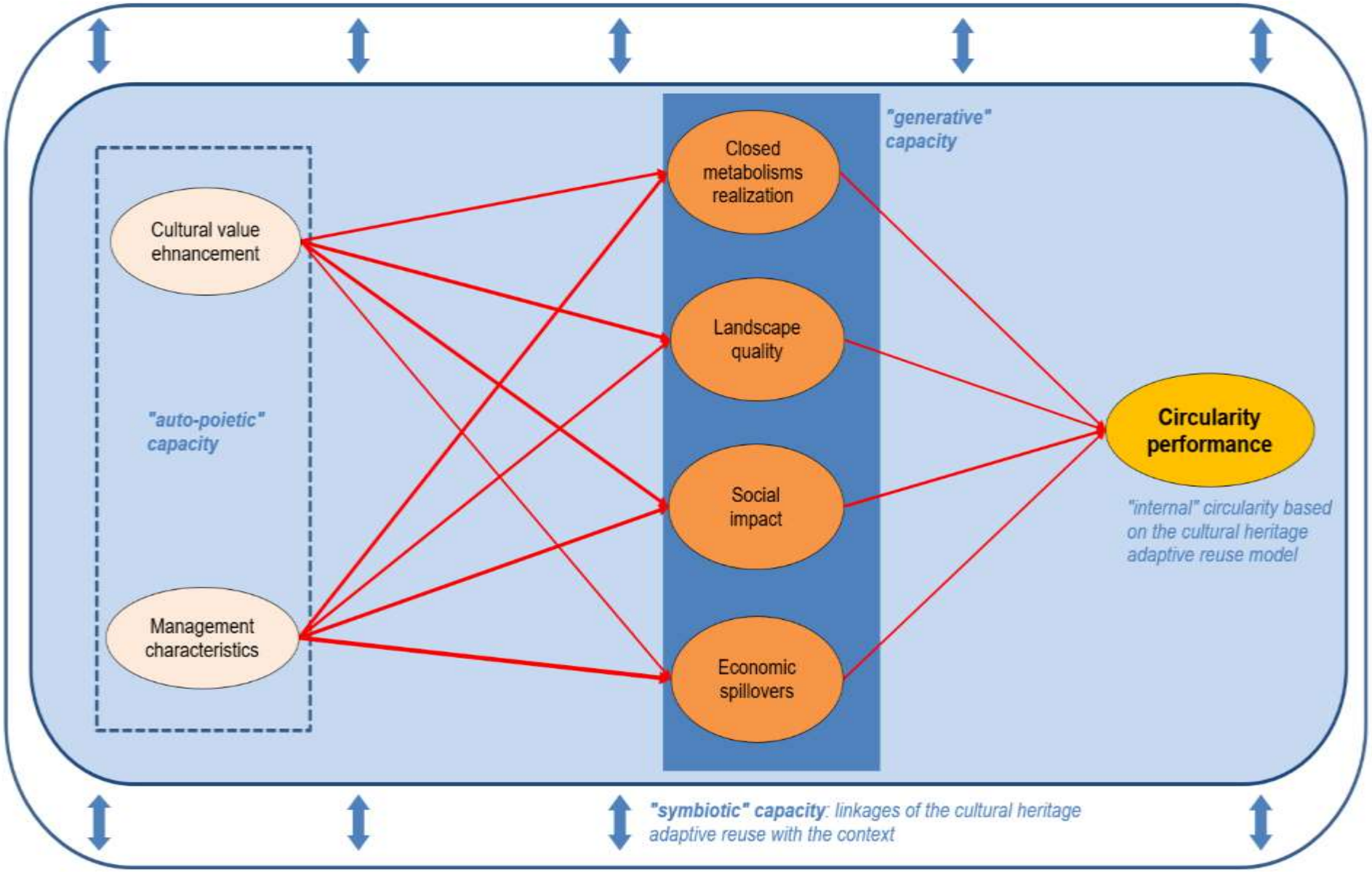
"Endogenous" Latent Variables (which impact on Circularity performance):

- **Closed metabolism realization at micro-level**
- **Landscape quality enhancement**
- **Social impact**
- **Economic spillover effects**

Final Latent Variable (determined by the previous Latent Variables):

- **Circularity performance**

Source: Horizon 2020 CLIC project - Deliverable 1.3 - Survey on best practices of cultural heritage adaptive reuse. Authors: Gravagnuolo A, Fusco Girard L, Vellecco I, Lauro N C. 2019. Section 3.2 Identification of Best Practices: a modelling-based approach.



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Assessment of «circularity» performance of 126 adaptive reuse cases in Europe

- **Manifest Variables.** The Manifest Variables were associated to the Latent Variables in a reflexive way considering the answers to the 31 questions of the assessment on circularity, as well as one additional variable related to the “uses” section, considering the number of uses counted and classified in 5 groups (1-5 uses; 6-10 uses; 11-15 uses; 16-20 uses; more than 20 uses).

Source: Horizon 2020 CLIC project - Deliverable 1.3 - Survey on best practices of cultural heritage adaptive reuse. Authors: Gravagnuolo A, Fusco Girard L, Vellecco I, Lauro N C. 2019. Section 3.2 Identification of Best Practices: a modelling-based approach.

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LV1 – Cultural value enhancement

- MV1.1 – Conservation of heritage values
- MV1.2 – Awareness raise for circular economy

Source: Horizon 2020 CLIC project - Deliverable 1.3 - Survey on best practices of cultural heritage adaptive reuse. Authors: Gravagnuolo A, Fusco Girard L, Vellecco I, Lauro N C. 2019. Section 3.2 Identification of Best Practices: a modelling-based approach.

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LV2 – Management characteristics and self-sustainability

- MV2.1 – Economically and financially self-sustainable
- MV2.2 – Generates revenue flows
- MV2.3 – Third sector involved
- MV2.4 – Different stakeholders involved
- MV2.5 – Profits are reinvested
- MV2.6 – Total number of uses (classified in 5 groups)

Source: Horizon 2020 CLIC project - Deliverable 1.3 - Survey on best practices of cultural heritage adaptive reuse. Authors: Gravagnuolo A, Fusco Girard L, Vellecco I, Lauro N C. 2019. Section 3.2 Identification of Best Practices: a modelling-based approach.

Assessment of «circularity» performance of 126 adaptive reuse cases in Europe

LV3 – Closed metabolism realization

- MV3.1 –Low energy consumption systems
- MV3.2 –Renewable energy sources
- MV3.3 –Water storage and reuse systems
- MV3.4 –Traditional / bio / reuse materials
- MV3.5 –Reduction of construction waste

Source: Horizon 2020 CLIC project - Deliverable 1.3 - Survey on best practices of cultural heritage adaptive reuse. Authors: Gravagnuolo A, Fusco Girard L, Vellecco I, Lauro N C. 2019. Section 3.2 Identification of Best Practices: a modelling-based approach.

Assessment of «circularity» performance of 126 adaptive reuse cases in Europe

LV4 – Landscape quality enhancement

- MV4.1 – Increase of green spaces
- MV4.2 – Quality of public spaces
- MV4.3 – Enhance safety in the area
- MV4.4 –Enhance landscape visual quality

Source: Horizon 2020 CLIC project - Deliverable 1.3 - Survey on best practices of cultural heritage adaptive reuse. Authors: Gravagnuolo A, Fusco Girard L, Vellecco I, Lauro N C. 2019. Section 3.2 Identification of Best Practices: a modelling-based approach.

Assessment of «circularity» performance of 126 adaptive reuse cases in Europe

LV5 – Social impact

- MV5.1 –Awareness raise for cultural heritage
- MV5.2 –Enhance place attachment
- MV5.3 –Enhance social cohesion
- MV5.4 –Enhance inclusion of marginalized groups
- MV5.5 –Enhance heritage community
- MV5.6 –Enhance cultural activities
- MV5.7 –Enhance people's wellbeing
- MV5.8 –Enhance people's health

Source: Horizon 2020 CLIC project - Deliverable 1.3 - Survey on best practices of cultural heritage adaptive reuse. Authors: Gravagnuolo A, Fusco Girard L, Vellecco I, Lauro N C. 2019. Section 3.2 Identification of Best Practices: a modelling-based approach.

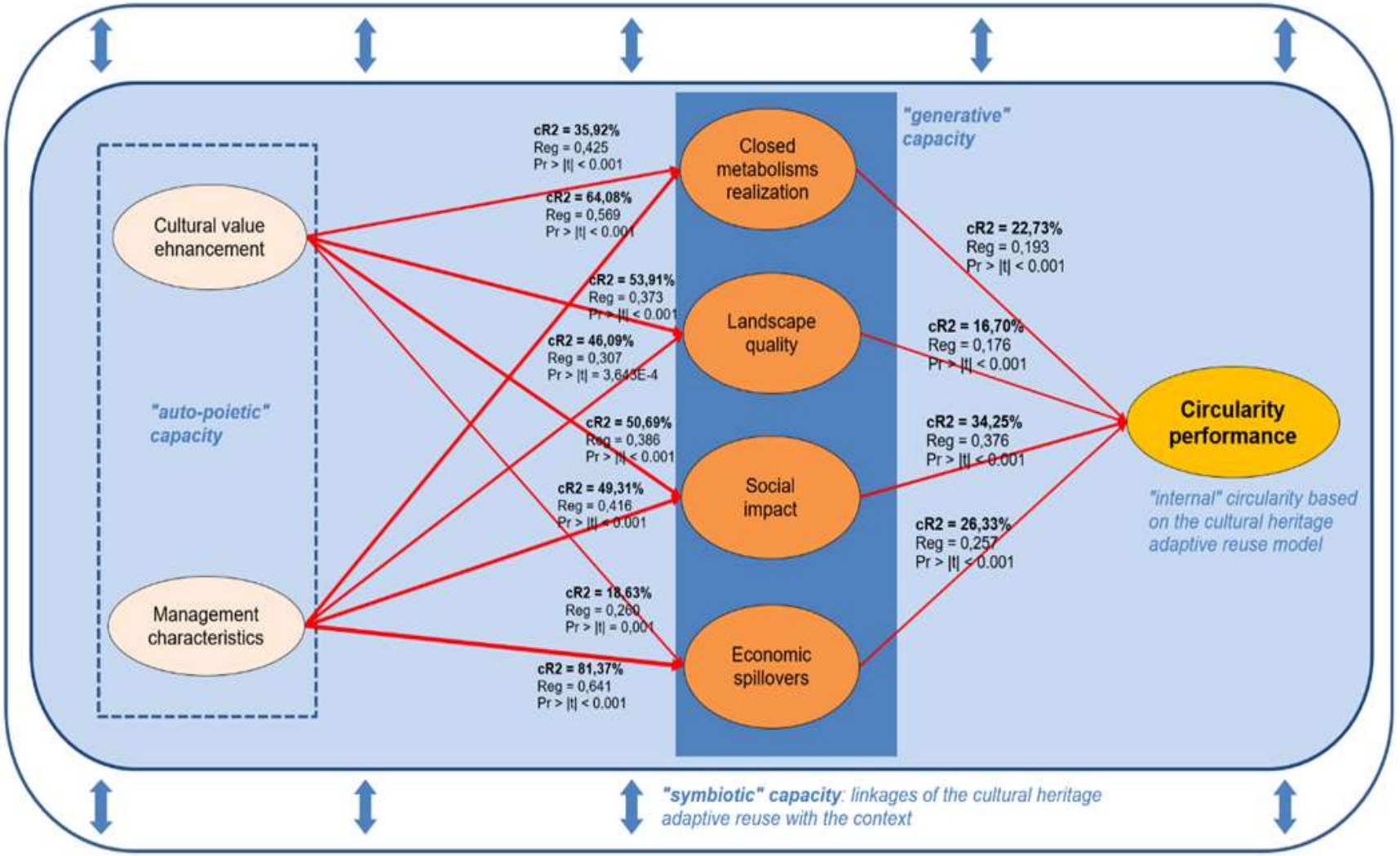
Assessment of «circularity» performance of 126 adaptive reuse cases in Europe

LV6 – Economic spillover effects

- MV6.1 – Enhance jobs creation
- MV6.2 – Attract innovative start-ups
- MV6.3 – Attract creative industries
- MV6.4 – Attract new commercial activities
- MV6.5 – Attract cultural visitors
- MV6.6 – Attract new residents
- MV6.7 – Increase real estate values

Source: Horizon 2020 CLIC project - Deliverable 1.3 - Survey on best practices of cultural heritage adaptive reuse. Authors: Gravagnuolo A, Fusco Girard L, Vellecco I, Lauro N C. 2019. Section 3.2 Identification of Best Practices: a modelling-based approach.

Circularity structural model results



Consistency of the model: Internal consistency of the model has been verified (unidimensionality, monofactoriality)

Source: Horizon 2020 CLIC project - Deliverable 1.3 - Survey on best practices of cultural heritage adaptive reuse. Authors: Gravagnuolo A, Fusco Girard L, Vellecco I, Lauro N C. 2019. Section 3.2 Identification of Best Practices: a modelling-based approach.

Cross-loadings (Monofactorial Manifest Variables)

	Cultural value	Management characteristics	Closed metabolisms	Landscape quality	Social impact	Economic spillovers	Circularity performance
HERITAGE VALUE	**0,748**	0,252	0,283	0,314	0,514	0,290	0,430
CE AWARENESS	**0,763**	0,239	0,399	0,336	0,355	0,347	0,422
FINANCIAL SELF-SUSTAINABILITY	0,045	**0,399**	0,142	0,105	0,142	0,141	0,161
REVENUE FLOWS	0,362	**0,670**	0,490	0,315	0,359	0,502	0,499
THIRD SECTOR	0,071	**0,574**	0,052	0,185	0,346	0,378	0,307
STAKEHOLDERS INVOLVEMENT	0,138	**0,565**	0,285	0,255	0,477	0,326	0,421
REINVESTMENT OF PROFITS	0,301	**0,762**	0,503	0,357	0,437	0,540	0,552
TOT n. of uses_C	0,010	**0,484**	0,223	0,060	0,139	0,381	0,253
LOW ENERGY SYSTEMS	0,320	0,258	**0,717**	0,328	0,365	0,416	0,550
RENEWABLE ENERGY	0,215	0,388	**0,748**	0,506	0,361	0,513	0,628
WATER RECOVERY	0,364	0,514	**0,866**	0,587	0,501	0,519	0,727
MATERIALS REUSED	0,358	0,444	**0,681**	0,325	0,395	0,348	0,514
WASTES REDUCTION	0,414	0,403	**0,701**	0,286	0,409	0,428	0,544
GREEN SPACES	0,299	0,161	0,530	**0,501**	0,345	0,172	0,445
PUBLIC SPACE QUALITY	0,208	0,295	0,252	**0,748**	0,502	0,486	0,576
SAFETY	0,387	0,317	0,428	**0,759**	0,589	0,379	0,624
LANDSCAPE QUALITY	0,304	0,346	0,374	**0,770**	0,529	0,345	0,579
CH AWARENESS	0,518	0,298	0,373	0,433	**0,718**	0,389	0,593
PLACE ATTACHMENT	0,504	0,393	0,462	0,544	**0,713**	0,358	0,627
SOCIAL COHESION	0,350	0,437	0,350	0,549	**0,744**	0,458	0,648
INCLUSION	0,397	0,347	0,265	0,525	**0,565**	0,312	0,499
HERITAGE COMMUNITY	0,271	0,488	0,374	0,409	**0,702**	0,581	0,648
CULTURAL ACTIVITIES	0,334	0,378	0,239	0,441	**0,630**	0,468	0,550
WELLBEING	0,349	0,407	0,457	0,479	**0,678**	0,456	0,640
HEALTH	0,359	0,370	0,427	0,456	**0,625**	0,378	0,577
JOBS CREATION	0,276	0,409	0,474	0,265	0,444	**0,625**	0,559
STARTUP ATTRACTION	0,291	0,521	0,448	0,301	0,420	**0,715**	0,575
CREATIVE INDUSTRIES	0,215	0,429	0,136	0,234	0,364	**0,630**	0,423
COMMERCIAL ACTIVITIES	0,312	0,385	0,430	0,288	0,346	**0,627**	0,515
CULTURAL TOURISM	0,456	0,298	0,239	0,413	0,441	**0,484**	0,469
RESIDENTS ATTRACTION	0,274	0,556	0,444	0,399	0,439	**0,736**	0,613
REAL ESTATE INCREASE	0,116	0,501	0,530	0,382	0,439	**0,762**	0,648

Source: Horizon 2020 CLIC project - Deliverable 1.3 - Survey on best practices of cultural heritage adaptive reuse. Authors: Gravagnuolo A, Fusco Girard L, Vellecco I, Lauro N C. 2019. Section 3.2 Identification of Best Practices: a modelling-based approach.

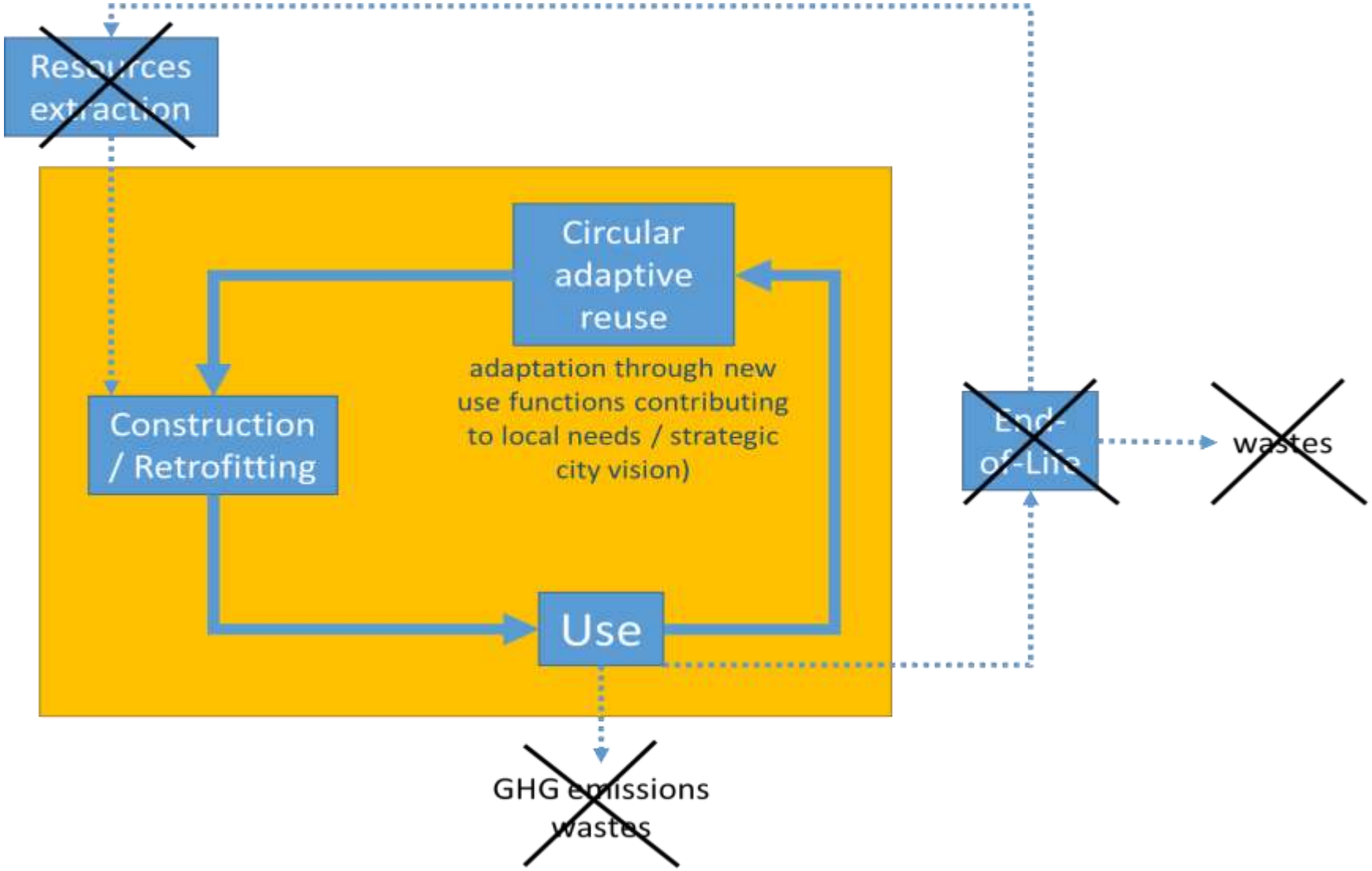
Circular Urban Metabolism assessment model proposal

The **Circular/Closed Urban Metabolism assessment model** starts from the results obtained through the SEM and takes into account three main elements:

- The **Objectives** of the Circular/Closed Urban Metabolism model: auto-poietic capacity, generative capacity and symbiotic capacity;
- The **Life-Cycle stages**: (1) extraction/production, (2) use, (3) end-of-life vs. reuse;
- The **Criteria** (linked to attributes and indicators) represent the lens point of view though which the CHAR is evaluated.

Circular Urban Metabolism assessment model proposal

The **circular adaptive reuse model** aims at reducing environmental negative externalities, re-generating the cultural heritage through new use functions and updated environmentally efficient technologies over time (retrofitting).



Circular Urban Metabolism assessment model proposal

Multicriteria assessment matrixes can be built considering this theoretical model.

1. Extraction – Production stage	***Auto – poiesis***	***Generative capacity***	***Symbiotic capacity***
Criterion 1	*Attr.* 11	*Attr.* 12	*Attr.* 13
Criterion 2	*Attr.* 21	*Attr.* 22	*Attr.* 23
Criterion 3	*Attr.* 31	*Attr.* 32	*Attr.* 33
…	…	…	…

2. Use stage	***Auto – poiesis***	***Generative capacity***	***Symbiotic capacity***
Criterion 1	*Attr.* 11	*Attr.* 12	*Attr.* 13
Criterion 2	*Attr.* 21	*Attr.* 22	*Attr.* 23
Criterion 3	*Attr.* 31	*Attr.* 32	*Attr.* 33
…	…	…	…

3. End – of – life/Reuse stage	***Auto – poiesis***	***Generative capacity***	***Symbiotic capacity***
Criterion 1	***Attr.* 11**	***Attr.* 12**	***Attr.* 13**
Criterion 2	***Attr.* 21**	***Attr.* 22**	***Attr.* 23**
Criterion 3	***Attr.* 31**	***Attr.* 32**	***Attr.* 33**
…	…	…	…

Circular Urban Metabolism assessment model proposal

- The alternatives are here considered as possible adaptive reuse projects based on the new uses / functions proposed.

- It is here assumed that **each alternative of use / function (or mix of uses/functions) contributes differently to the objectives of the Circular Urban Metabolism**: auto-poietic capacity, generative capacity and symbiotic capacity. This means that **each function / mix of functions should be assessed based on its contribution to these three objectives**.

First conclusions

- The adoption of the **circular economy model in the cultural heritage adaptive reuse** does not refer only to the reuse of materials, water, resources, energy, etc. and to the reduction of wastes.
- It refers also to the **transformation, as far as possible, of a "non-place" into a new attractive pole / "place"**. This is in relation with the **auto-poietic ecosystem production** having significant implications on **evaluation tools**, and in particular with the search of the ***human scale* of the local development** (New Urbanism Charter, New Urban Agenda).
- The ***human scale*** is implemented ***through cultural heritage adaptive reuse*** transforming spaces into beautiful places for living, working, meeting and so on, interpreting the circular economic model in this way.

First conclusions

- The **Urban Metabolism (UM) assessment** and **Multi-Criteria Analysis (MCA), Multi-group, quantitative-qualitative analysis** can be integrated to assess the **contribution of cultural heritage adaptive reuse to the implementation of the circular city-region model**.

- The **Circular Urban Metabolism assessment model** proposed could represent a viable model to assess different adaptive reuse projects, considering their **single, as well as synergic / systemic contribution** to the **city-region productivity**.

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