

## Supplementary Materials for the article:

# Indicators for ex-post evaluation of cultural heritage adaptive reuse impacts in the perspective of the circular economy

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**Abstract:** Cultural heritage (CH) is considered a key element of cities and regions' identity and uniqueness, contributing to peoples' wellbeing and health, as well as jobs creation, environmental regeneration and place attractiveness. The adaptive reuse of abandoned and underused CH can be a sustainable strategy for heritage conservation, stimulating local development processes. However, heritage conservation needs large investments, while the resources available are scarce, and investment projects are subject to high uncertainties. Therefore, a careful assessment of impacts is needed to orient and direct CH adaptive reuse projects towards sustainability. Recent studies approach the adaptive reuse of abandoned buildings and sites as an effective circular economy strategy, potentially contributing to climate objectives through environmental regeneration and the reduction of natural resources consumption. However, evaluation tools to assess the impacts and orient adaptive reused interventions in the perspective of circularity are lacking. Through the analysis of 76 literature sources on CH impacts, this article explores how indicators are currently used in CH research and practice as impact assessment tools. More than 3500 indicators were retrieved and classified. Finally, this article proposes a comprehensive evaluation framework to assess the impacts of cultural heritage adaptive reuse in the perspective of the circular economy. The results showed that, while some indicators are available, many circularity aspects are not considered in the current studies on CH impacts.

**Keywords:** multidimensional indicators; evaluation tools; cultural heritage; adaptive reuse; circular economy; circular city; impact assessment; built environment; sustainable development

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**Appendix A.** Literature sources on cultural heritage impact sectors and indicators. Ec: Economic indicators, S: Social Indicators, En: Environmental Indicators, C: Cultural Indicators.

Source	Year	Source typology	Number of indicators	Dimensions				Scale	Phase	Typology	
				Ec	S	En	C			Quant	Qualit
Nijkamp	1989	Article	6	3			3	Meso	Ex-post	3	3
Pearson et al.	1998	Institutional Report	139	19	9	36	75	Meso	Ex-post	137	2
Greffe	2004	Article	4	4				Meso	Ex-post	4	
Hockings et al.	2008	Institutional Report	17	2	7	5	3	Meso	Ex-post	17	
Labadi	2011	Institutional Report	57	24	22	7	4	Meso	Ex-post	35	22
Rypkema and Cheong	2011	Article	29	16	17	6		Meso	Ex-post	8	21
Licciardi and Amirtahmasebi	2011	Institutional Report	13	4	7	2		Meso	Ex-post	7	6
Zancheti and Hidaka	2011	Article	3				3	Meso	Ex-post		3
Elsorady	2014	Article	16	1	3	3	9	Micro	Ex-ante		16
CHCfE Consortium	2015	Research Report	54	18	13	9	14	Meso	Ex-post	32	22
Fusco Girard et al.	2015	Article	124	77	14	15	18	Meso	Ex-post	121	3
James	2015	Article	40	8	16	9	7	Meso	Ex-post	35	22
Sowińska-Świerkosz	2017	Article	15	3	1	7	4	Meso	Ex-post	10	5
Guzmán et al.	2017	Article	14		4	6	4	Meso	Ex-post	12	2
Nocca	2017	Article	178	111	35	1	31	Meso	Ex-post	172	6
Stanik et al.	2018	Article	6			2	4	Macro	Ex-post	3	3
Vecco and Srakar	2018	Article	7	2	1	1	3	Macro	Ex-post	7	
Airaghi et al.	2019	Research Report	13	12	1			Meso	Ex-post	13	
Historic England	2019	Research Report	41	7	5	7	22	Macro	Ex-post	41	
Günçe and Mısırlısoy	2019	Article	25	5	4	6	10	Micro	Ex-post		25
Della Spina	2020	Article	11	6		4	1	Micro	Ex-ante	4	7
De Leão Dornelles et al	2020	Article	1				1		Ex-post		1
Melloni et al.	2020	Research Report	144	19	82	7	36	Meso	Ex-post	121	23

**Appendix B.** Literature sources on other impact sectors and indicators. Ec: Economic indicators, S: Social Indicators, En: Environmental Indicators, C: Cultural Indicators.

Source	Year	Source typology	Number of indicators	Dimensions				Scale	Phase	Typology	
				Ec	S	En	C			Quant	Qualit
Mercer	2002	Institutional Report	373	56	204	21	92	Macro	Ex-post	181	192
WTO	2004	Institutional Report	29	6	7	16		Macro	Ex-post	24	5
OCPA Task Force		Institutional Report	64	15	21	2	26	Macro	Monitorin g	21	43
Home Affairs Bureau	2005	Institutional Report	27	7	10		10	Macro	Ex-post	12	15
Choi and Sirakaya	2006	Article	98	16	42	30	10	Meso	Ex-post	35	63
OECD	2006	Institutional Report	104	68	26		10	Macro	Ex-post	103	1
Jackson et al.	2006	Research Report	53	16	9	1	27	Macro	Ex-post	46	7
UNESCO	2007	Institutional Report	21	3	3		15	Meso	Ex-post	19	2
UNESCO	2007	Institutional Report	23	11	8		4	Macro	Ex-post	23	
Institut de la statistique du Québec	2007	Institutional Report	67	29	29		9	Macro	Ex-post	56	11
OECD	2008	Institutional Report	31	20	3	1	7	Macro	Ex-post	21	10
Ministry for Culture and Heritage	2009	Institutional Report	17	5	5		7	Macro	Ex-post	15	2
KEA European Affairs	2009	Institutional Report	11	3	5		3	Macro	Ex-post	11	
NCCRS	2010	Institutional Report	16	6	4		6	Macro	Ex-post	16	
UNESCO	2010	Institutional Report	312	83	99	15	115	Macro	Ex-post	177	135
Ngamsomsuke et al.	2011	Article	20	4	3	7	6	Macro	Ex-post		20
Daschko	2011	Institutional Report	47	5	28	2	12	Macro	Ex-post	7	40
Ministry of Culture and Education of Finland	2011	Institutional Report	116	54	33	3	26	Macro	Ex-post	105	11
ESS-net-CULTUR	2012	Research Report	28	9	11		8	Macro	Ex-post	28	
Lozano Oyola et al.	2012	Article	62	20	6	28	8	Meso	Ex-post	54	8
Montalto	2012	Institutional Report	23	13	5	1	4	Meso	Ex-post	16	7

UNESCO and UNDP	2013	Research Report	54	23	18	2	11	Macro	Ex-post	44	10
Columbia Basin Rural Development Institute	2013	Research Report	164	48	36	6	74	Macro	Ex-post	94	70
Oxford Economics	2013	Research Report	4	4				Macro	Ex-post	4	
UCLG	2014	Institutional Report	57		34	5	18	Meso	Ex-post		57
ARTS COUNCIL ENGLAND	2014	Institutional Report	59		51		8	Micro	Ex-post		59
UNESCO	2014	Institutional Report	22	2	13		7	Macro	Ex-post	16	6
United Nations	2015	Institutional Report	53	12	27	8	6	Macro	Ex-post	53	
Global network “Future we want includes culture”	2015	Institutional Report	28	2	8	5	13	Macro	Ex-post	26	2
Kushner and Cohen	2016	Research Report	17	15	2			Macro	Ex-post	28	
Council of Europe	2016	Institutional Report	26	5	14		7	Macro	Ex-post	16	10
University of Baltimore	2016	Institutional Report	56	6	27	18	5	Meso	Ex-post	53	3
Blancas et al.	2016	Article	52	26	11	12	3	Macro	Ex-post	52	
European Commission	2016	Research Report	43	14	10	18	1	Meso	Ex-post	41	2
UNESCO	2017	Institutional Report	60	6	20	13	21	Macro	Ex-post	36	24
Ortega-Villa and Ley-Garcia	2017	Article	19		12		7	Meso	Ex-post	4	15
Rei and Huan	2018	Article	67	14	18	24	11	Micro	Ex-post	41	26
ISTAT	2018	Research Report	2	2				Macro	Ex-post	2	
EUROSTAT	2019	Research Report	14	3	2		9	Macro	Ex-post	12	2
EUROSTAT	2019	Research Report	9	1	4	4		Macro	Ex-post	9	
UNESCO	2019	Research Report	21	7	6	1	7	Macro	Ex-post	1	8
Montalto et al.	2019	Article	12	4	4		4	Meso	Ex-post	7	5
ISTAT	2018	Research Report	11	2	3	6		Macro	Ex-post	9	2
Asmelash and Kumar	2019	Article	61	10	31	12	8	Macro	Ex-post	14	47
European Commission	2019	Website	16	8	2	6		Macro	Ex-post	14	2

European Commission	2019	Institutional Report	29	3	21	5	Meso	Ex-post	23	6
OECD and ICOM	2019	Institutional Report	8	2	6		Macro	Monitoring	2	6
Compendium of Cultural Policies & Trends	2019	Website	26	8	11	7	Macro	Ex-post	18	8

**Appendix C.** Literature sources on Circular Economy impact sectors and indicators. Ec: Economic indicators, S: Social Indicators, En: Environmental Indicators, C: Cultural Indicators.

Source	Year	Source typology	Number of indicators	Dimensions				Scale	Phase	Typology	
				Ec	S	En	C			Quant	Qualit
Gravagnuolo et al. [36]	2019	Article	17			17		Meso	Ex-post	17	
Historic England [141]	2019	Research Report	2			2		Micro	Ex-post	2	
Foster and Kreinin [43]	2020	Article	12			12		Micro	Ex-post	12	
Foster et al. [44]	2020	Article	20			20		Micro	Ex-post	20	
Heisel and Rau-Oberhuber [142]	2020	Article	3			3		Micro	Ex-post	3	