HORIZON 2020 EUROPEAN UNION FUNDING FOR RESEARCH & INNOVATION
CIRCULAR MODELS LEVERAGING INVESTMENTS IN CULTURAL HERITAGE ADAPTIVE REUSE

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Interaction and projects interdependence in portfolio decision analysis for CULTURAL HERITAGE

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1. Keywords

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Cultural Heritage

is an expression of the ways of living developed by a community and passed on from generation to generation, including customs, practices, places, objects, artistic expressions and values

Adaptive Reuse

is a process of reusing an old site or building for a purpose other than which it was built or designed for

Circular Economy

is an economy that balances economic development with environmental and resources protection (Regenerate; Share; Optimize; Loop; Virtualize, and Exchange)

Decision support system

is an information system that supports decision-making activities, helping the people making decisions about problems that cannot be easily specified in advance

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2. About the CLIC project

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Purpose

Supporting the public sector to identify **"circular" financing, business and governance models** for systemic adaptive reuse of cultural heritage and landscape

Proposal

Designing, developing and validating a **decision support system** for the public administrations

Testing in **Salerno** (Italy), **Rijeka** (Croatia), and **Västra Götaland Region** (Sweden)

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Partners

- **Institute for Research on Innovation and Services for Development (IRISS), National Research Council** (Italy)
- Uppsala University (Sweden)
- ICHEC Brussels Management School (Belgium)
- University College London (UK)
- Eindhoven University of Technology TU/e (The Netherlands)
- **University of Portsmouth, Business School** (UK)
- University of Nova Gorica (Slovenia)
- Vienna University of Economics and Business, Institute for Ecological Economics (Austria)
- Robert Zajonc Institute for Social Studies, University of Warsaw (Poland)
- ICLEI - Local Governments for Sustainability (Germany)
- FacilityLive (Italy)
- **Västra Götalands Regionen** (Sweden)
- **Rijeka** (Croatia)
- **Salerno** (Italy)
- Pakhuis de Zwijger Foundation (The Netherlands)

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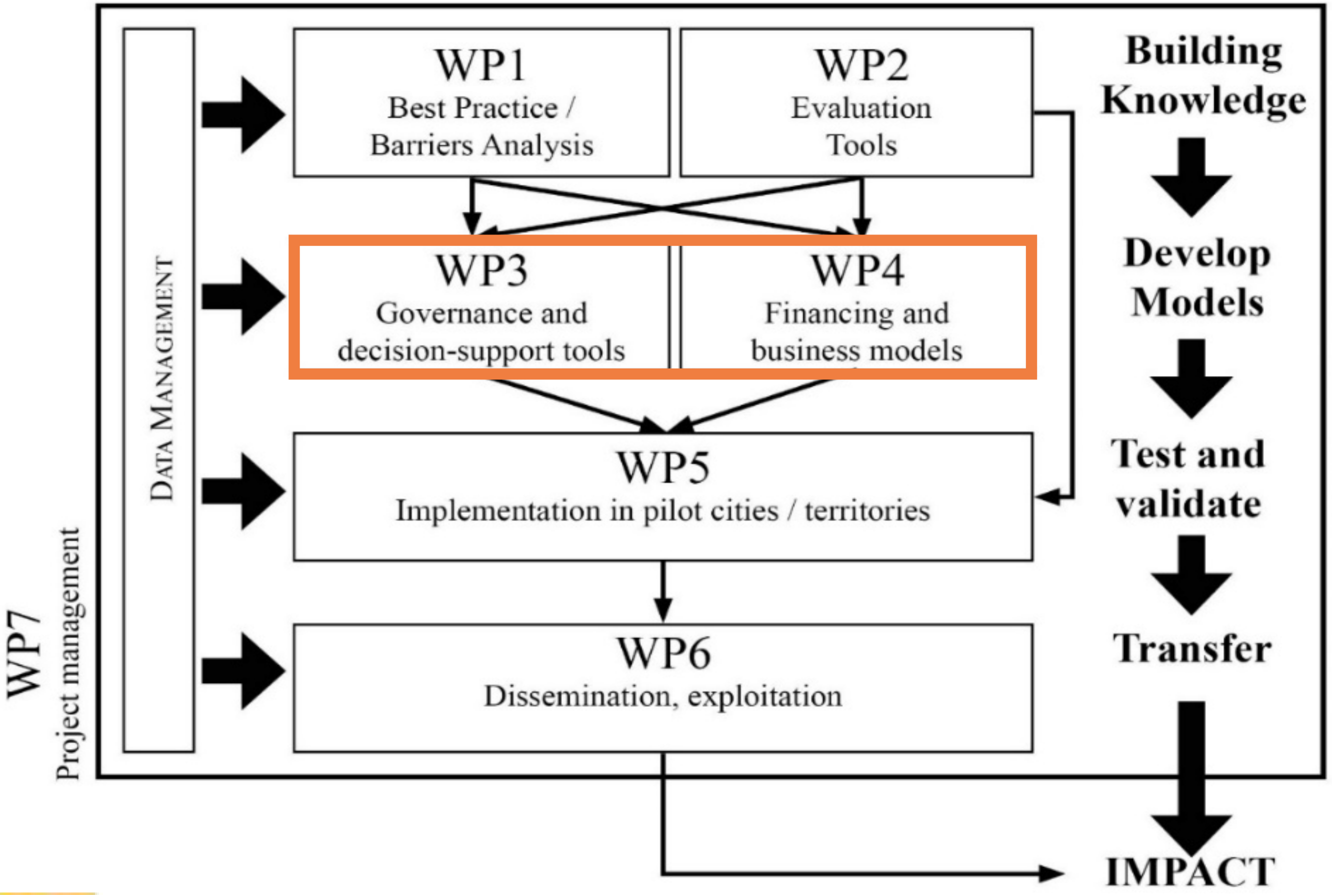
Work Packages



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3. CLIC Decision support system

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Steps

1. Identifying the elements of the decision problem for each city/region

- Typology of feasible projects
- Criteria and indicators to evaluate the feasible projects
- Actors involved

2. Designing the methodology

- Definition of the mathematical approach
- Prototype of the decision support system
- Pilot tests

3. Real world applications

- Collection of preference information
- Implementation of decision support system
- Presentation and discussion of the results with the actors

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Salerno **Problem**

Description

4 large **historical buildings** in the high part of the historical city centre

Important buildings for the history of the cities, but they are now **abandoned**

Objective: to define a sustainable strategy of these sites according to **social use** and **financial** constraints

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Rijeka **Problem**

Description

2 Buildings of the
industrial heritage
1 Historic ship

The city will be **European Capital of Culture** in 2020. The city is improving the cultural offer

Objective: to define a sustainable strategy of these sites post Rijeka 2020

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Västra Götaland **Problem**

Description

5 Buildings of the industrial heritage in 5 different cities

The region wants to improve the cultural offer

Objective: to define a strategy that reuse these buildings together

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Features of decision support system

- Supporting the **interaction of actors**
- Considering the **several aspects** (cultural, environmental, social, economic, financial) of the problem
- Analysing **qualitative** and **quantitative** data
- Analysing **geographic** data
- Considering the **interactions** between the different aspects or elements of the problem
- Collecting **preference** information and supplying **results** in an easy and understandable way

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4. About the methodology

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Interactive approach

Dominance-based Rough Set Approach to Interactive Multiple Objective Optimization (DRSA-IMO)

Greco, S., Matarazzo, B., Slowinski, R.: Dominance-Based Rough Set Approach to Interactive Multiobjective Optimization, in J.Branke, K.Deb, K.Miettinen, R.Slowinski (eds.), *Multiobjective Optimization: Interactive and Evolutionary Approaches*. Springer, Berlin, 2008, pp.121-156.
Barbati, M., Greco, S., Kadziński, M., & Słowiński, R. (2018). Optimization of multiple satisfaction levels in portfolio decision analysis. *Omega*, 78 192-204

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Steps

1. Present to the DM a set of **representative efficient solutions**
2. If the **DM finds a satisfactory solution**, then end; else go to the next step
3. The DM **marks** efficient solutions considered as (relatively) **good**
4. DRSA “*if...,then...*” **decision rules** are induced
5. The most interesting **decision rules are presented to the DM**
6. The **DM selects one decision rule** being the most adequate to his/her preferences
7. **Constraints** relative to this decision rule are adjoined
8. Go back to **step 1**

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Example

Criteria G_1	Max G_1
Criteria G_2	Min G_2
Criteria G_3	Max G_3
Criteria G_4	Max G_4
Criteria G_5	Max G_5
Criteria G_6	Max G_6

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Example

Set of representative efficient solutions

Solutions	G_1	G_2	G_3	G_4	G_5	G_6
S1	165	120	0	0	10	250
S2	172.6923	130	0.7692	0	10	265.3846
S3	180.3846	140	1.5384	0	10	280.7692
S4	141.125	140	3	3	4.916667	272.9167
S5	148.375	150	5	2	4.75	278.75
S6	139.125	150	5	3	3.583333	279.5833
S7	188.0769	150	2.3076	0	10	296.1538
S8	159	150	6	0	6	270
S9	140.5	150	6	2	3.666667	271.6667
S10	209.25	200	6	2	7.833333	375.8333
S11	189.375	200	5	5	5.416667	385.4167
S12	127.375	130	3	3	4.083333	252.0833
S13	113.625	120	3	3	3.25	231.25

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Example

Sorting of representative efficient solutions

Solutions	G_1	G_2	G_3	G_4	G_5	G_6	Class
S1	165	120	0	0	10	250	*
S2	172.6923	130	0.7692	0	10	265.3846	*
S3	180.3846	140	1.5384	0	10	280.7692	Good
S4	141.125	140	3	3	4.916667	272.9167	Good
S5	148.375	150	5	2	4.75	278.75	Good
S6	139.125	150	5	3	3.583333	279.5833	*
S7	188.0769	150	2.3076	0	10	296.1538	*
S8	159	150	6	0	6	270	*
S9	140.5	150	6	2	3.666667	271.6667	Good
S10	209.25	200	6	2	7.833333	375.8333	*
S11	189.375	200	5	5	5.416667	385.4167	*
S12	127.375	130	3	3	4.083333	252.0833	*
S13	113.625	120	3	3	3.25	231.25	*

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Example

The most interesting **DRSA decision rules**

If $G_1 \geq 140.5$ and $G_2 \leq 150$ and $G_4 \geq 2$, then is good (s4,s5,s9)

If $G_2 \leq 140$ and $G_3 \geq 1.538462$ and $G_5 \geq 10$, then is good (s3)

If $G_2 \leq 150$ and $G_4 \geq 2$ and $G_5 \geq 4.75$, then is good (s4,s5)

If $G_2 \leq 140$ and $G_6 \geq 272.9167$, then is good (s3,s4)

If $G_2 \leq 150$ and $G_4 \geq 2$ and $G_5 \geq 3.666667$ and $G_6 \geq 271.6667$, then is good (s4,s5,s9)

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Example

Selected **decision rule**

The DM selected the following rule as the most adequate to his/her preferences:

If $\mathbf{G_1 \geq 140.5}$ **and** $\mathbf{G_2 \leq 150}$ **and** $\mathbf{G_4 \geq 2}$**,**
then is good (s4,s5,s9)

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Example

Set of representative efficient solutions **(second iteration)**

Solutions	G_1	G_2	G_3	G_4	G_5	G_6
S1’	186.53	150	0.15	2	10	313.07
S2’	154.87	150	3	3	5.75	293.75
S3’	172	150	2	2	8	300
S4’	162.75	150	2	3	6.83	300.83
S5’	174	140	0	2	9.33	293.33
S6’	158.25	140	2	2	7.16	279.16
S7’	149	140	2	3	6	280
S8’	160.25	130	0	2	8.5	272.5
S9’	144.5	130	2	2	6.33	258.33
S10’	153.375	125	0	2	8.08	262.08
S11’	145.5	125	1	2	7	255
S12’	141.5625	125	1.5	2	6.45	251.45

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Example

Sorting of representative efficient solutions **(second iteration)**

Solutions	G_1	G_2	G_3	G_4	G_5	G_6	Class
S1’	186.53	150	0.15	2	10	313.07	*
S2’	154.87	150	3	3	5.75	293.75	*
S3’	172	150	2	2	8	300	Good
S4’	162.75	150	2	3	6.83	300.83	Good
S5’	174	140	0	2	9.33	293.33	*
S6’	158.25	140	2	2	7.16	279.16	Good
S7’	149	140	2	3	6	280	*
S8’	160.25	130	0	2	8.5	272.5	*
S9’	144.5	130	2	2	6.33	258.33	*
S10’	153.375	125	0	2	8.08	262.08	*
S11’	145.5	125	1	2	7	255	Good
S12’	141.5625	125	1.5	2	6.45	251.45	Good

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Example

The most interesting **DRSA decision rules**

If **$G_2 \leq 125$ and $G_3 \geq 1$**,
then is good **(s11’,s12’)**

If **$G_3 \geq 1$ and $G_5 \geq 7$**,
then is good **(s3’,s6’,s11’)**

If **$G_1 \geq 158.25$ and $G_3 \geq 2$**,
then is good **(s3’,s4’,s6’)**

If **$G_3 \geq 1.5$ and $G_5 \geq 6.46$**,
then is good **(s3’,s4’,s6’,s12’)**

If **$G_3 \geq 2$ and $G_6 \geq 300$**,
then is good **(s3’,s4’)**

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Example

Selected **decision rule**

The DM selected the following rule as the most adequate to his/her preferences:

If $G_1 \geq 158.25$ and $G_3 \geq 2$,
then is good (s3',s4',s6')

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Example

Set of representative efficient solutions (third iteration)

Solutions	G_1	G_2	G_3	G_4	G_5	G_6
S1''	165.125	145	2	2	7.58	289.58
S2''	158.25	150	2	3.48	6.26	301.23
S3''	158.25	145	2	2.74	6.71	290.20
S4''	158.25	140	2	2	7.16	279.16
S5''	164.125	150	3	2	6.91	292.91
S6''	158.25	145.72	3	2	6.56	284.01

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Example

Set of representative efficient solutions **(third iteration)** and the **selected solution**

Solutions	G_1	G_2	G_3	G_4	G_5	G_6	Class
S1''	165.125	145	2	2	7.58	289.58	**Selected**
S2''	158.25	150	2	3.48	6.26	301.23	*
S3''	158.25	145	2	2.74	6.71	290.20	*
S4''	158.25	140	2	2	7.16	279.16	*
S5''	164.125	150	3	2	6.91	292.91	*
S6''	158.25	145.72	3	2	6.56	284.01	*

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Example

The most interesting **DRSA decision rules**

If $G_1 \geq 165.125$,
then is good (s1'')

If $G_5 \geq 7.58$,
then is good (s1'')

The DM selected the first decision rule.

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Example

Explanation and justification of the decision

Solution s1'' has been selected because it satisfies the three following rules:

If $G_1 \geq 140.5$ and $G_2 \leq 150$ and $G_4 \geq 2$, then is good

If $G_1 \geq 158.25$ and $G_3 \geq 2$, then is good

If $G_1 \geq 165.125$, then is good

Therefore solution s1'' has been selected because it has

$G_1 \geq 165.125$

$G_2 \leq 150$

$G_3 \geq 2$

$G_4 \geq 2$

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5. Conclusion

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Important remarks about the method

1. The method is based on **ordinal properties** of values of objective functions **only**
2. At each step, the method **does not aggregate** the objective functions **in a single value** (**no scalarization** is involved)
3. DM gives **preference information** by answering **easy questions** in terms of holistic sorting, **without use of any technical parameters**, such as weights, tradeoffs, thresholds,...
4. **Decision rules** are important in a **learning oriented perspective**

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Decision rules

- are easily **understandable** and **intelligible** for actors (“**glass box**”)
- enable **argumentation, explanation** and **justification** of the final decision (as a conclusion of a **decision process, not** just as a **mechanical application** of a technical approach)

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Thank you for your attention

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