Beyond Linear Impact: A Nonlinear Theory of Change and a Six-Level Indicator System for Evaluating Culture-Led Regeneration in Left-behind Territories

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Abstract. Left-behind territories have characteristics that are not easily identified using traditional impact assessment methods, in particular with regard to cultural-led initiatives. Evaluating cultural-led regeneration processes of such territories requires new assessment models capable of capturing processes of transformation that unfold across cognitive, relational, behavioural and socio-economic dimensions simultaneously. This paper presents a nonlinear, systemic Theory of Change (ToC) grounded in the capabilities approach and in the 4E cognition framework, implemented as part of the Metroborgo Observatory for the municipality of Montalto delle Marche (Marche region, Italy), selected as one of the beneficiary municipalities of the 'Bando Borghi' Line A under the Italian National Recovery and Resilience Plan (PNRR). The model conceptualises cultural investment as an activator of cognitive and relational processes, reconfiguring predictive models, expanding perceived agency and consolidating social cohesion, rather than as a direct generator of economic outcomes. The paper describes the resulting six-level indicator system comprising 36 indicators. It integrates composite indices derived from Likert-scale questionnaire items with direct indicators from secondary sources, including administrative records, business register data and mobile network-derived visitor flow estimates. The architecture is designed for longitudinal, independent-samples comparison and for disaggregated sub-group analysis, with explicit methodological provisions for addressing compositional confounds in low-density demographic contexts. The model contributes to the debate on multidimensional and evolutionary evaluation by proposing a socio-cognitive-behavioural framework that makes non-linear transformation processes observable and comparable over time.

Keywords: Theory of Change · Culture-led regeneration · Capabilities approach · 4E cognition · Indicator systems · Left-behind territories · Place-based development · Mixed-methods evaluation

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1 Introduction

The evaluation of cultural-led regeneration processes faces a persistent structural tension. On one side lies the need for measurable, accountable outcomes that satisfy the requirements of public funders and programme managers; on the other, the recognition that the most significant effects of cultural investment, for instance on individual agency, social cohesion, place identity and long-term behavioural change, are complex, distributed over time and not directly traceable to specific inputs.

Standard impact evaluation frameworks, including the logical framework approach (LFA) and its derivatives, address this tension by positing a linear causal chain from inputs to outputs, outcomes and impact. This scheme is both practically tractable and institutionally legible, but it systematically underestimates the role of intermediate cognitive and relational mechanisms through which cultural interventions generate effect.

In territories characterised by structural marginalisation, that is small municipality in mountain or inland areas with declining population, weak institutional capacity and limited economic alternatives, this underestimation risks to produce evidence that confirms the operational success of a programme while remaining blind to whether it has modified the conditions that generate territorial decline.

This paper presents the theoretical architecture and indicator system developed for the Metroborgo Observatory, a cultural impact monitoring initiative for Montalto delle Marche, a small municipality (2,300 inhabitants) in the inland Marche region of central Italy. The Observatory is designed to evaluate the medium- and long-term impact of a broad cultural regeneration programme, such as the "Bando Borghi" Line A of the Italian National Recovery and Resilience Plan (PNRR).

The contribution of the paper is twofold. First, it presents a nonlinear Theory of Change grounded in the capabilities approach and in the 4E cognition framework, which conceptualises cultural investment as an activator of cognitive and relational processes rather than as a direct generator of economic outcomes. Second, it describes the six-level indicator system that operationalises this ToC, integrating composite indices, derived from a purpose-built questionnaire, with direct indicators from secondary administrative and statistical sources.

The paper is structured as follows. Sect. 2 reviews the limitations of linear ToC models in cultural and territorial evaluation and introduces the systemic alternative. Sect. 3 presents the theoretical framework. Sect. 4 describes the questionnaire. Sect. 5 discusses the indicator system and its methodological architecture. Sect. 6 concludes.

2 Theorethical Framework

2.1 The Limitis of Linear Models in the Evaluation of Cultural-Led Processes

The standard Theory of Change approach [1] is based on an input-output-outcome logic inherited from programme theory [2, 3]. Resources invested generate activities; activities produce outputs; outputs, under the right conditions, generate intended outcomes; outcomes accumulate into long-term impact. This sequential structure is well-suited for the understanding of public funders or programme managers, or for any interventions where the causal mechanisms is recognizable because of clear competence targets. In cultural

regeneration processes, however, this linearity is structurally insufficient for at least three reasons. First, the mechanisms through which cultural interventions produce effects are not merely transactional but cognitive and relational. That means that they operate by modifying how people perceive and relate to their environment. The effect of opening a cultural space depends primarily on whether the experience reconfigures expectations, activates latent agency or consolidates community bonds. Second, the temporal structure of impact is non-linear. Some effects are rapid and easily observable (participation rates, visitor numbers), while others, namely changes in perceived self-efficacy, in the local sense of place, in the propensity to invest, are slow-forming, cumulative and only detectable over multiple observation cycles. Third, in structurally marginalised territories, the presence of an aesthetic trap [4] means that heritage valorisation and cultural activation do not automatically translate into expanded life chances for residents: without an effect on internal representations and perceived opportunity sets, even substantial investment may fail to generate systemic activation. The ToC adopted in the Metroborgo Observatory responds to these limitations by integrating three complementary theoretical bodies, described in the following paragraphs.

2.2 Capabilities Approach and Territorial Development

The capabilities approach, as originally formulated by Amartya Sen è [5] and further developed by Martha Nussbaum [6] and Ingrid Robeyns [7], distinguishes between resources (means), functionings (achieved states of being and doing) and capabilities (real opportunities to achieve those functionings). Applied to territorial development, and in particular to the place-based development paradigm [8], this framework redefines the objective of public investment as the expansion of the conditions under which local actors can effectively convert available opportunities into choices and actions.

Cultural regeneration, in this perspective, is about expanding territorial capabilities, namely the ensemble of conditions (cognitive, relational, material) that make it possible for residents to imagine, choose and construct their collective future rather than increasing cultural supply or tourist attractiveness. This reframing has direct evaluative implications: the relevant question whether the intervention has modified the perceived capacity of people to contribute to territorial life, strengthened the relational fabric that enables collective action, and generated new orientations toward the future.

2.3 4E Cognition, Embodied Simulation and the Aesthetic Trap

The 4E model of cognition [9] describes cognition as a process that is embodied, which means shaped by bodily states and sensorimotor capacities), enacted, namely constituted through action-environment interaction, extended, or distributed beyond the boundaries of the brain into tools and built environments, and embedded, i.e. shaped by social and material context. This framework dissolves the boundary between individual cognition and environmental affordances, making the built and cultural environment a cognitive resource that shapes how people perceive and act.

Embodied simulation theory [10] further specifies the mechanism. Cultural experiences are active simulations capable of mobilizing the motor, emotional and sensory resonance systems. Narrative devices, spatial configurations and participatory practices

act as predictive scaffolds that can modify the internal models with which individuals anticipate what the territory can offer them [11]

The predictive processing framework [11, 12] provides the formal architecture for understanding this process. Under this account, the brain continuously generates top-down predictions about sensory input and updates its generative model in response to prediction errors, namely discrepancies between what is expected and what is encountered. Action and perception are jointly optimised to minimise expected free energy, a quantity that bounds the long-run surprise an organism will encounter. Crucially, the system does not weight all prediction errors equally. Precision weighting determines which errors are treated as informative and which are suppressed. High precision assigned to a prediction error amplifies its influence on model updating; low precision attenuates it.

In structurally marginalised territories, this cognitive dimension is particularly critical. We have previously introduced the concept of the aesthetic trap [8], a condition in which the cultural and landscape heritage of a territory is valorised and recognised without this valorisation translating into transformed opportunity sets for residents. Residents who have experienced prolonged economic decline and institutional neglect develop generative models characterised by low expected precision on signals of opportunity: positive developments are discounted as noise rather than treated as evidence that the environment has changed. The trap can be understood in these terms as a condition in which the sensory richness of heritage and landscape generates positive valence without triggering the prediction errors necessary to update the generative model of territorial agency.

2.4 Integrating Capabilities and Predictive Processing

The capabilities approach and the predictive processing operate within different field (normative political philosophy and computational cognitive sciences respectively) but we can state that they converge on a shared structural insight. Capabilities, indeed, depend on conversion factors that determine whether a formally available resources becomes a substantive freedom. On the other hand, we can posit a conversion factor in predictive processing terms as a set of precision-weighted priors that determine whether an available opportunity generates a tractable action policy, one whose expected free energy is low enough to be selected over the default of inaction.

On this account, capabilities expansion is the reconfiguration of the generative model such that previously available but subjectively inaccessible options become actionable. A resident who has always had the formal possibility of starting a local enterprise but whose generative model assigns high expected free energy to that action (anticipating failure, bureaucratic obstruction, social disapproval) does not possess the corresponding capability in any substantive sense. The capability becomes real when the precision structure shifts. That is, when new evidence, for example a successful peer, a supportive institutional signal, an embodied experience of competence in a cultural workshop, updates the model sufficiently to lower the expected free energy of acting.

This integration has two consequences for evaluation design. First, it identifies the critical intermediate variable the transformation of the precision-weighted generative models that mediate between them (Levels 2-3, § 4.3). Second, it explains why the same intervention can succeed in one context and fail in another: the effect depends on the

prior state of the generative model and on the precision the intervention manages to assign to the prediction errors it generates.

3 A Non Linear Theory of Change: Six Interdependent Levels

3.1 The Model

From this theoretical architecture, our ToC takes the form of a dynamic, circular model represented as concentric rings, each corresponding to a level of analysis and measurement (Fig. 1).

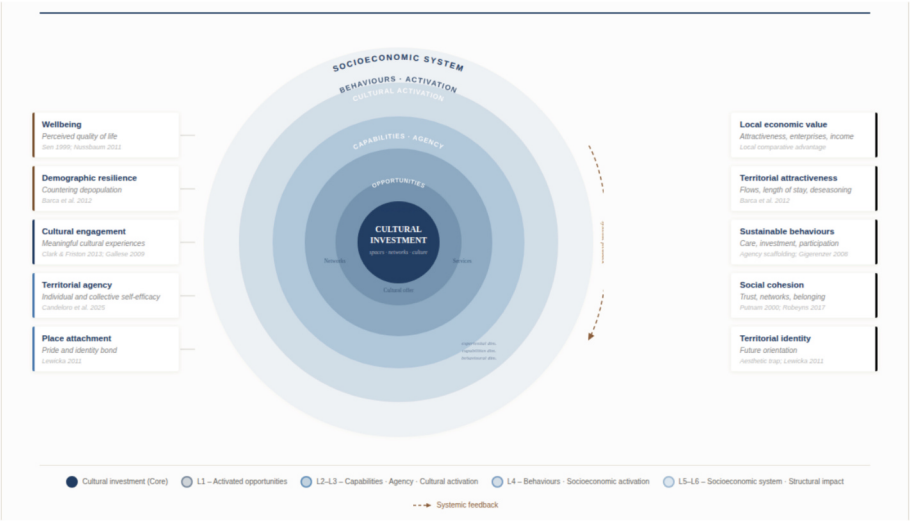

Fig. 1. The Non-Linear Theory of Change

Level 1 | Outputs and Activated Opportunities. The innermost ring represents the direct and immediately observable results of cultural investment: the recovery of architectural heritage, the activation of cultural spaces, cultural programming, the establishment of new businesses, the mobilisation of public and private resources, and the construction of collaborative networks among local actors. These elements constitute an expansion of the opportunity set available to the territory, but do not yet represent impact. They are the necessary precondition for the activation of subsequent levels, not its sufficient cause.

Level 2 | Capabilities and Agency. The second level concerns the transformation of the cognitive and relational conditions that determine whether the opportunities generated at Level 1 are effectively accessible and convertible into action. Four dimensions are operative here. Self-efficacy [13] captures the perceived capacity of individuals to contribute actively to territorial life and to initiate or participate in local initiatives. In predictive processing terms, self-efficacy corresponds to the precision assigned to action–outcome

contingencies: high self-efficacy reflects a generative model in which one's own actions are expected to produce meaningful effects. Social cohesion [14] encompasses the trust, collaboration and sense of community belonging that enable the conversion of individual capacity into collective action [15]. Place attachment [16] captures the emotional and identity bond with the territory, which the literature identifies as a predictor of behaviours of care, permanence and investment. For visitors, the quality of the visit experience constitutes the relational condition for deeper forms of engagement.

Level 3 | Cultural Activation. The third level captures the cognitive and emotional activation generated by cultural experiences, understood not as mere attendance at events but as an active process of sense-making and horizon-expansion. Cultural engagement describes the degree to which an experience reconfigures the predictive models through which individuals anticipate what the territory can offer them. In the terms developed in Sects. 2.4, this is where the precision structure shifts: effective cultural engagement generates the salient prediction errors that force model revision in the domain of agency and territorial possibility. This is the pivotal level of the model: it is the mechanism through which the opportunity expansion of Level 1 begins to modify the capabilities structures of Level 2, and through which the conditions for behavioural activation at Level 4 are generated.

Level 4 | Behaviours and Socioeconomic Activation. The fourth level captures the observable translation of expanded capabilities and cultural engagement into concrete practices. For residents, this means sustainable behaviours toward public spaces, attention to the future consequences of present choices, and civic participation. For visitors, it means responsible behaviours, local value creation, and intention to return. This level is the critical threshold at which change could become consolidable since behaviours, unlike attitudes, are observable by third parties, generate external effects and can be reinforced or disrupted by the social environment.

Level 5 | Socioeconomic System Outcomes. The fifth level captures the cumulative effects of the transformations at Levels 1-4 on the socioeconomic system of the territory. Subjective wellbeing, perceived income and property value changes, perceived environmental quality and business dynamics are tracked through both questionnaire and administrative sources. The outcomes at this level are not directly generated by investment. Rather, they emerge from the cumulative interaction of opportunity expansion, capability transformation, cultural activation and behavioural consolidation at the preceding levels.

Level 6 | Structural Cohesion and Demographic Dynamics. The outermost ring represents the long-term structural dimension of territorial transformation, detectable only over multiple years of observation. Population trends, age structure, new residents, voluntary participation, mutual-aid networks, perceived security, access to essential services, cultural inclusion and institutional capacity define the evaluative horizon of the model: the ultimate criterion of success is not increased visitor numbers or short-term investment, but whether the territory has become more capable, more cohesive and more demographically sustainable.

3.2 Cross-Level Dynamics and Evaluation Implication

The circular shape of the model is shown for clarity of exposition, but the six levels do not operate in a fixed sequence. Level 3 cultural engagement can precede and generate Level 2 capability changes rather than following them; Level 4 behavioural practices can reinforce Level 2 social cohesion; Level 5 economic outcomes feed back into the Level 1 opportunity set, modifying the context in which new investment is designed and implemented. A significant cultural experience can strengthen place attachment; stronger place attachment can stimulate behaviours of care; diffuse care behaviours can improve perceived environmental quality; improved environmental quality can attract new visitors or temporary residents; such attraction can generate economic effects that redefine the opportunity set for the next planning cycle.

This nonlinearity has specific consequences for evaluation design. Three are worth highlighting. First, the indicator system must support cross-level association analysis at the aggregate level: the capacity to test, for instance, whether population-level increases in Level 3 cultural engagement scores in wave t are associated with population-level increases in Level 2 self-efficacy scores in wave $t + 1$, or whether Level 4 behavioural activation co-varies with Level 2 social cohesion within the same wave. Because the design relies on independent samples rather than individual tracking (see Sect. 5.2), these associations are detectable as shifts in population distributions across waves, not as within-person trajectories; they provide indirect evidence for the feedback dynamics posited by the model, but do not support strict causal mediation inference. Second, the evaluation must accommodate differential temporal signatures across levels: rapid effects at Levels 1 and 3 (infrastructure delivery, event-driven engagement), medium-term consolidation at Levels 2 and 4 (capability and behavioural change), and slow structural shifts at Levels 5 and 6. A purely synchronic snapshot would collapse these temporal strata. Third, the distinction between shallow and deep interventions has measurable consequences: shallow interventions produce rapid, easily observable effects at Levels 3-4 that may not persist once the scaffolding is removed; deep interventions produce slower changes at Level 2 that, once consolidated, generate self-sustaining behavioural trajectories at Level 4. The indicator system is designed to detect both levels of effect and to track the processes of consolidation through which shallow activations may deepen over time.

4 Indicator System and Instrumentation

4.1 Architecture and Design Principles

The indicator system operationalises the nonlinear ToC through 36 indicators organised across six levels. The architecture is designed around three principles. First, multi-source triangulation: each level integrates at least one primary source (questionnaire) and, where available, secondary administrative or statistical sources, ensuring cross-validation and reducing the risk of source-specific bias. Second, methodological complementarity: composite indices and direct observational indicators are treated as analytically distinct but interpretively integrated capturing subjective and relational dimensions inaccessible to

administrative data and anchoring the evaluation in externally verifiable facts. Third, longitudinal comparability: all instruments maintain invariant structure across observation cycles, enabling independent-samples comparison over time.

The following subsections describe each level's indicators and their questionnaire operationalization in a single integrated presentation. The primary data collection instrument is a purpose-built questionnaire structured in four groups. Group 0 contains a routing question (G0Q00: «Do you live in or regularly visit Montalto delle Marche?») that directs respondents to either the residents' module (Group 1, annual administration) or the visitors' module (Group 2, seasonal administration). Groups 3 and 4 are common to both. The instrument is designed for mixed administration, online via link or QR code and assisted in-person, to reduce digital exclusion risk in a small, partially elderly population.

The residents' module opens with a profiling question on length of residence or regular frequentation (G1Q01: less than 1 year / 1-5 / 6-10 / over 10 / lifelong), used for sub-group disaggregation and for the compositional confound mitigation strategy described in Sect. 5.2. The visitors' module opens with six profiling questions covering first-visit status (G2Q01), type of visit, day trip, weekend or extended stay (G2Q02), main motivation, namely work, study or leisure (G2Q03), group composition (G2Q04), and event participation (G2Q05-G2Q06). These variables are not included in the indicator matrix but are essential for sub-group disaggregation, equity analysis and the detection of differential activation patterns across visitor types.

Both modules include closing items that fall outside the indicator system. The residents' module closes with a question on whether the respondent believes the project can foster new enterprises in the cultural, creative and tourism sectors (G1Q10) and an optional open-ended question on expected changes in territorial and personal life (G1Q11). The visitors' module closes with an optional open-ended question on the most significant aspect of the experience (G2Q13). Group 4 collects sociodemographic contextual variables: gender including non-binary option (G4Q01), age bracket (G4Q02), educational attainment (G4Q03) and occupation (G4Q04), which are indispensable for sub-group disaggregation but are not part of the indicator system.

4.2 Level 1:Outputs and Activated Opportunities

Seven indicators capture the direct results of cultural investment. Five are drawn from administrative and accounting sources: recovered architectural heritage (m^2), cultural spaces activated, cultural programming (events/year), new businesses established, and investments mobilized (€). Two perception-based indicators complete the level: satisfaction with investments (G3Q05) and perceived external visibility (G4Q05), both measured as single items on five-point ordinal and binary scales respectively. These indicators establish the factual baseline of what has been done and confirm that the intervention has generated an expanded opportunity set.

4.3 Level 2-3: Capabilities, Agency and Cultural Activation

Six composite indices capture the transformation of internal representations and relational conditions that the ToC posits as the critical intermediate mechanism.

At Level 2, the residents' module contributes three composite indices. Territorial agency / self-efficacy (G1Q02) comprises four Likert 1-7 items probing: the sense of being able to contribute actively to territorial life; the perception of being capable of acting in the face of local problems or opportunities; the sense of being heard when expressing ideas or proposals; and confidence in one's own capacity to initiate or participate in local initiatives. Social cohesion (G1Q03-Q05) comprises three Likert 1-7 items measuring perceived collaboration, sense of community belonging and mutual trust, complemented by two binary closure questions assessing the specific effect of the Metroborgo project: whether the respondent has perceived an improvement in social life (G1Q04) and whether they have engaged in dialogue with people from different cultural backgrounds (G1Q05). The binary items are analyzed as direct indicators (percentage distributions) and interpreted jointly with the Likert composite, enabling a degree of programme-attributional inference while preserving integrity. Place attachment (G1Q06) comprises four Likert 1-7 items: emotional bond with the place, pride in living there, identity connection, and anticipated regret of having to leave. The visitors' module contributes a quality-of-visit-experience index (G2Q07, four items: overall experience quality, sense of welcome, clarity and accessibility of spaces, perceived authenticity).

At Level 3, cultural engagement is measured via two five-item composite indices, one for residents (G1Q07) and one for visitors (G2Q08). The residents' items investigate participation in local cultural activities; stimulation toward new learning; reflection on the territory's present and future; sense of active involvement rather than passive spectatorship; and the role of culture in daily life. The visitors' items inquire understanding of the territory facilitated by activities; new learning; active involvement; emotional impact of places and stories; and capacity for reflection. Both indices are grounded in the predictive processing framework developed in Sect. 2.4: their items are designed to capture not mere attendance but experiences of novelty, disrupted expectations and expanded horizons that the theoretical model identifies as the mechanism of cognitive reconfiguration. An additional direct indicator, associative and civic participation, is drawn from municipal records and periodic surveys.

4.4 Level 4: Behaviours and Socioeconomic Activation

Five indicators capture the observable translation of expanded capabilities into practices. Sustainable behaviours among residents (G1Q08, four Likert 1-7 items) investigate attention to the care of public spaces; consideration of the future consequences of present choices; reduction of environmental impact in daily life; and adoption of respectful behaviours in public and cultural spaces. Responsible behaviours among visitors (G2Q09, four items) investigate respect for places and people; attention to the impact of one's own actions; awareness of the territory's value gained during the visit; and sense of responsibility toward future visits. Local value creation by visitors (G2Q10, five items) tracks interaction with local people; use of local services and products; perception of having contributed positively to the territory; propensity to recommend the experience; and intention to return or extend the stay. Two direct indicators complete the level: propensity to local investment (G3Q06–Q07, recording whether the respondent has made economic investments as a result of the project, and their approximate amount

by bracket) and visitor expenditure broken down by category (G2Q12: accommodation, food and drink, local products, transport, cultural activities).

4.5 Level 5: Socioeconomic System Outcomes

Eight indicators cover subjective wellbeing and system-level effects. Two composite indices measure wellbeing; for residents (G1Q09, five Likert 1-7 items: life satisfaction in the territory, perception of the place as wellbeing-promoting, contribution of social relationships to quality of life, positive perspectives on the community's future, mental and emotional wellbeing); for visitors (G2Q11, five items: general wellbeing during the visit, relaxation and stimulation, sense of connection with the place, enrichment of time, positive feeling at departure). Three direct ordinal indicators use five-point scales: perceived income change (G3Q01), perceived property value change (G3Q02) and perceived environmental quality (G3Q03). A further direct ordinal indicator tracks the influence of project investments on quality of life (G3Q04). These four items, though sharing the same response format, measure conceptually distinct constructs and are therefore treated as separate direct indicators. Two secondary-source indicators complete the level: local economy and businesses (business registers, INPS, ISTAT) and tourist attractiveness (ISTAT, accommodation records, mobile network-derived visitor flow estimates).

4.6 Level 6: Structural Cohesion and Demographic Dynamics

Ten indicators track the long-term structural dimension of territorial transformation: population trend, age structure / dependency ratio, new residents, participation and volunteering, proximity networks and mutual aid, social conflict and integration, perceived security, access to essential services, inclusion and accessibility, and institutional capacity. These indicators are derived primarily from administrative sources (ISTAT, municipal registry) and periodic surveys to be activated in subsequent phases of the Observatory, once a consolidated baseline has been established at Levels 1-5. This level is included in the matrix from the very beginning, before the data are available, because it specifies the evaluative horizon of the model (Table 1).

Table 1. Six.level indicator matrix for the Metrobrgo Observatory

Level	Dimension	Indicator	Source	Type
L1	Outputs	Recovered architectural heritage (m^2)	Municipal office / OpenCoesione	Direct
L1	Outputs	Cultural spaces activated	Municipality / managers	Direct
L1	Outputs	Cultural programming (events/year)	Cultural office / AMAT	Direct
L1	Outputs	New businesses established	Business register / INPS	Direct

(*continued*)

Table 1. (*continued*)

Level	Dimension	Indicator	Source	Type
L1	Outputs	Investments mobilised (€)	Accounting / OpenCoesione	Direct
L1	Outputs	Perceived quality of investments (G3Q05)	Questionnaire	Direct
L1	Outputs	External visibility (G4Q05)	Questionnaire	Direct
L2	Capabilities / Agency	Territorial agency - self-efficacy (G1Q02, 4 items)	Questionnaire Likert 1-7	Composite
L2	Capabilities / Agency	Social cohesion (G1Q03-Q05, 3 + 2 items)	Questionnaire Likert 1-7 + binary	Composite
L2	Capabilities / Agency	Place attachment (G1Q06, 4 items)	Questionnaire Likert 1-7	Composite
L2	Capabilities / Agency	Quality of visit experience (G2Q07, 4 items)	Questionnaire Likert 1-7	Composite
L3	Cultural Activation	Cultural engagement - residents (G1Q07, 5 items)	Questionnaire Likert 1-7	Composite
L3	Cultural Activation	Cultural engagement - visitors (G2Q08, 5 items)	Questionnaire Likert 1-7	Composite
L3	Cultural Activation	Associative and civic participation	Survey / Municipality	Direct
L4	Behaviours	Sustainable behaviours -residents (G1Q08, 4 items)	Questionnaire Likert 1-7	Composite
L4	Behaviours	Responsible behaviours - visitors (G2Q09, 4 items)	Questionnaire Likert 1-7	Composite
L4	Behaviours	Local value creation - visitors (G2Q10, 5 items)	Questionnaire Likert 1-7	Composite
L4	Behaviours	Propensity to local investment (G3Q06–Q07)	Questionnaire	Direct
L4	Behaviours	Visitor expenditure (G2Q12, by category)	Questionnaire	Direct

(*continued*)

Table 1. (*continued*)

Level	Dimension	Indicator	Source	Type
L5	Socioeconomic System	Subjective wellbeing - residents (G1Q09, 5 items)	Questionnaire Likert 1-7	Composite
L5	Socioeconomic System	Perceived wellbeing - visitors (G2Q11, 5 items)	Questionnaire Likert 1-7	Composite
L5	Socioeconomic System	Perceived income change (G3Q01)	Questionnaire ordinal	Direct
L5	Socioeconomic System	Perceived property value change (G3Q02)	Questionnaire ordinal	Direct
L5	Socioeconomic System	Perceived environmental quality (G3Q03)	Questionnaire ordinal	Direct
L5	Socioeconomic System	Influence on quality of life (G3Q04)	Questionnaire ordinal	Direct
L5	Socioeconomic System	Local economy and businesses	Business register / INPS / ISTAT	Direct
L5	Socioeconomic System	Tourist attractiveness	ISTAT / accommodation / mobile analytics	Direct
L6	Structural Cohesion	Population trend	ISTAT / Municipal registry	Direct
L6	Structural Cohesion	Age structure / dependency ratio	ISTAT / Municipal registry	Direct
L6	Structural Cohesion	New residents	Registry / periodic survey	Direct
L6	Structural Cohesion	Participation and volunteering	Periodic survey / Municipality	Direct
L6	Structural Cohesion	Proximity networks and mutual aid	Survey / Observation	Direct
L6	Structural Cohesion	Social conflict and integration	Survey / Interviews	Direct
L6	Structural Cohesion	Perceived security	Periodic survey	Direct
L6	Structural Cohesion	Access to essential services	Survey / Municipality	Direct
L6	Structural Cohesion	Inclusion and accessibility	Survey / Observation	Direct
L6	Structural Cohesion	Institutional capacity	Municipal budgets / Survey	Direct

5 Methods

5.1 Desk Data Collection

Secondary data analysis constitutes the structural layer of the Observatory's evaluation architecture. Desk data collection serves three evaluative functions: constructing a pre-intervention baseline, reconstructing the historical trajectory of the territory, and enabling comparative analysis with structurally similar territories.

The Italian National Institute of Statistics (ISTAT) provides the primary source for demographic monitoring (resident population, age structure, migratory balance) and for the socioeconomic framing of the municipality. In small municipalities, however, ISTAT data present significant interpretive constraints: publication lags, aggregation or suppression for privacy protection, high statistical volatility from small absolute numbers, and availability only at supra-municipal scale for some indicators. ISTAT data must therefore be read dynamically and accompanied by qualitative contextualisation.

The databases of Unioncamere and the local Chambers of Commerce provide the primary source for monitoring local economic dynamics: business birth and mortality rates, sectoral distribution, and the development of cultural and creative enterprises. The business register allows tracking of new enterprises across sectors, providing a direct desk-level signal for the Level 1 indicator 'new businesses established' and for the Level 5 indicator 'local economy and businesses', to be read in conjunction with INPS employment data. Records from the Revenue Agency and the Ministry of Economy enable analysis of income dynamics, the evolution of the local tax base, and real estate market trends via the Real Estate Market Observatory (OMI). OpenCoesione, the Italian government's open data platform for cohesion fund investments, enables tracking of public funds mobilised in the municipality across programmes and time periods. Complementary signals of economic activation are available from municipal administrative records on building permits, commercial licences and other administrative authorisations.

ISTAT's tourism statistics and data from local accommodation establishments provide the basis for monitoring tourist attractiveness. Accommodation-based statistics, however, systematically undercount visitor flows in small inland municipalities, where day-trippers and visitors staying with private contacts constitute a substantial share of total presence. To address this structural gap, the Observatory integrates official tourism data with aggregated and anonymised mobile network data (sourced from operators such as Vodafone Analytics or equivalent providers), which enable the estimation of total visitor numbers regardless of accommodation type, origin–destination pattern reconstruction, dwell time distributions and temporal presence curves at sub-municipal resolution. These sources are planned for activation in subsequent phases of the Observatory, once data access agreements have been established.

5.2 Index Construction, Validation and Longitudinal Comparison

All composite indices are constructed as arithmetic means of the constituent items, normalised to a 0- 100 scale using the transformation:

$$\text{Normalised index} = [(\text{mean score--}1)/6] \times 100.$$

This transformation preserves the metric properties of the Likert scale while producing a dimensionally interpretable score in which 0 corresponds to the minimum possible response (1 on all items) and 100 to the maximum (7 on all items), facilitating communication with non-specialist stakeholders and enabling cross-dimensional comparisons.

The use of arithmetic means as composite index scores rests on the assumption that the constituent items are unidimensional, that they load, in other words, on a single latent factor. This assumption will be tested empirically once a sufficient sample has been collected. At the baseline stage, the analytical plan includes internal consistency analysis via Cronbach's α for each composite index.

Longitudinal comparison across observation cycles is conducted as independent-samples analysis. Because the questionnaire does not include individual tracking identifiers, a deliberate design choice that reduces response bias and protects privacy in a small community, each wave constitutes a distinct sample. The comparison of index distributions across waves, using appropriate statistical tests for independent samples, effect size measures and confidence intervals, allows aggregate trend detection at the population level without requiring individual correspondence across editions. This choice is methodologically appropriate for low-density demographic contexts where panel construction is typically impracticable, but its implications warrant explicit acknowledgement. Independent-samples comparison measures changes in the distribution of a variable in the population, not changes in the same individuals over time. Observed shifts between waves may therefore reflect compositional effects, for instance, new residents with different socioeconomic profiles or stronger prior engagement entering the sample, rather than, or in addition to, genuine programme-induced change.

The primary mitigation strategy relies on the length-of-residence variable (G1Q01), which classifies respondents as recent arrivals (less than 1 year, 1–5 years) or long-established residents (6-10 years, over 10 years, lifelong). Disaggregated analysis by residential tenure allows the separation of two analytically distinct populations: those who were present before the intervention and may have experienced its effects directly, and those who arrived during or after its implementation, whose responses reflect a post-regeneration baseline rather than individual change. Comparing index distributions within each tenure subgroup across waves substantially reduces the compositional confound and enables more defensible causal attribution. This stratification is planned for activation from the second observation wave onward, once subsample sizes permit reliable inference.

The two binary closure questions on social cohesion (G1Q04-Q05), which ask whether the respondent has perceived a specific improvement in social life or has engaged in intercultural dialogue as a result of the Metroborgo project, provide a partial complement to the compositional limitation: a respondent who reports both increased social cohesion on the Likert scale and a programme-specific effect on the binary item supplies stronger attributional evidence than scale movement alone. Additional disaggregated analyses by age, gender and type of visit (G2Q02) are planned for successive waves, both for equity analysis and to detect differential patterns of activation across the capability and behavioural dimensions of the indicator system

6 Conclusion

This paper has presented a nonlinear Theory of Change and a six-level indicator system designed to evaluate cultural regeneration in left-behind territories. The framework departs from linear input-output-outcome models by grounding impact evaluation in a socio-cognitive-behavioural architecture that makes explicit the intermediate mechanisms (cognitive reconfiguration, relational activation, capability expansion) through which cultural investment generates territorial effects.

Three contributions stand out. First, the theoretical integration of the capabilities approach and predictive processing provides an empirically grounded and normatively rigorous account of why and how cultural interventions matter beyond their economic outputs. The identification of capability expansion as a shift in the precision-weighted generative models that mediate between formal opportunities and substantive freedoms connects the normative aspirations of the capabilities approach with a mechanistic account of how such expansion occurs at the cognitive level. Second, the six-level indicator system operationalises this account into a measurable, longitudinally comparable and decision-relevant framework, with explicit provisions for cross-level association analysis designed to detect the nonlinear dynamics the model posits. Third, the methodological architecture (composite indices with planned validation, direct indicators for specific observable facts, independent-samples longitudinal comparison, compositional confound mitigation through residential tenure stratification) provides a replicable template for impact evaluation in analogous territorial contexts.

The limitations of the present work are equally worth noting. The model is in its baseline phase: the first observation wave is underway and no longitudinal data are yet available. The causal claims embedded in the ToC, including the cross-level feedback dynamics that constitute its nonlinear character, remain partly hypothetical and will require empirical validation through successive waves. The psychometric properties of the composite indices await empirical confirmation. The independent-samples design, while appropriate for this context, limits the analysis to aggregate-level association rather than individual-level mediation; future phases may explore the feasibility of a voluntary panel subsample to complement the cross-sectional waves. The applicability of the framework to contexts beyond small Italian villages with a specific heritage-led regeneration profile will require adaptation and testing.

Future developments include the activation of Level 6 structural indicators through periodic surveys, the introduction of participatory indicators developed with community co-design methodologies, the elaboration of a simplified monitoring dashboard for non-specialist use by the local administration, and the empirical testing of cross-level association hypotheses once multi-wave data are available. The architecture of the Observatory is designed to support this evolutionary expansion: the ToC is not a fixed blueprint but a revisable hypothesis about how change happens, to be refined in light of what the evidence reveals.

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