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Smart Transition in Historical Small Towns: First In-sights from a Digital Material Flow Assessment in the Italian Case Study of Taurasi

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Rationale

- Historical Small Towns (HSTs) represent unique repositories of cultural heritage
- 70% of Italian municipalities have fewer than 5,000 inhabitants (54% of territory)
- Critical intersection of economic development, environmental conservation, and cultural identity preservation
- Industry 5.0 offers promising framework emphasizing human-centered, resilient, and sustainable approaches
- Focus on Taurasi (Campania) as case study for integrating digital flows into Urban Metabolism frameworks

Theoretical framework

Urban Metabolism & Material Flow Analysis

UM: "Total sum of technical and socio-economic processes in cities" (Kennedy, 2007).

MFA: Systematic assessment of flows and stocks of materials within a defined system (Brunner & Rechberger, 2016).

HSTs as complex adaptive systems managing selective flows of matter, energy, and information (Zellner & Campbell, 2015).

Theoretical framework

Industry 5.0 in Heritage Contexts

Human-centricity: Technology as augmentation rather than replacement (European Commission, 2021).

Resilience: Robust technologies for cultural heritage protection (Murphy et al., 2023).

Sustainability: Long-term development preserving visual identity (Nota & Petraglia, 2024)

Theoretical framework

Digital Flows Categories (Li et al., 2019)

Infrastructure Flows: Regional networks, IoT systems, smart grids

Information Flows: Environmental monitoring, digital documentation, resource management

Service Flows: E-government, digital preservation, smart applications (Yigitcanlar & Cugurullo, 2020)

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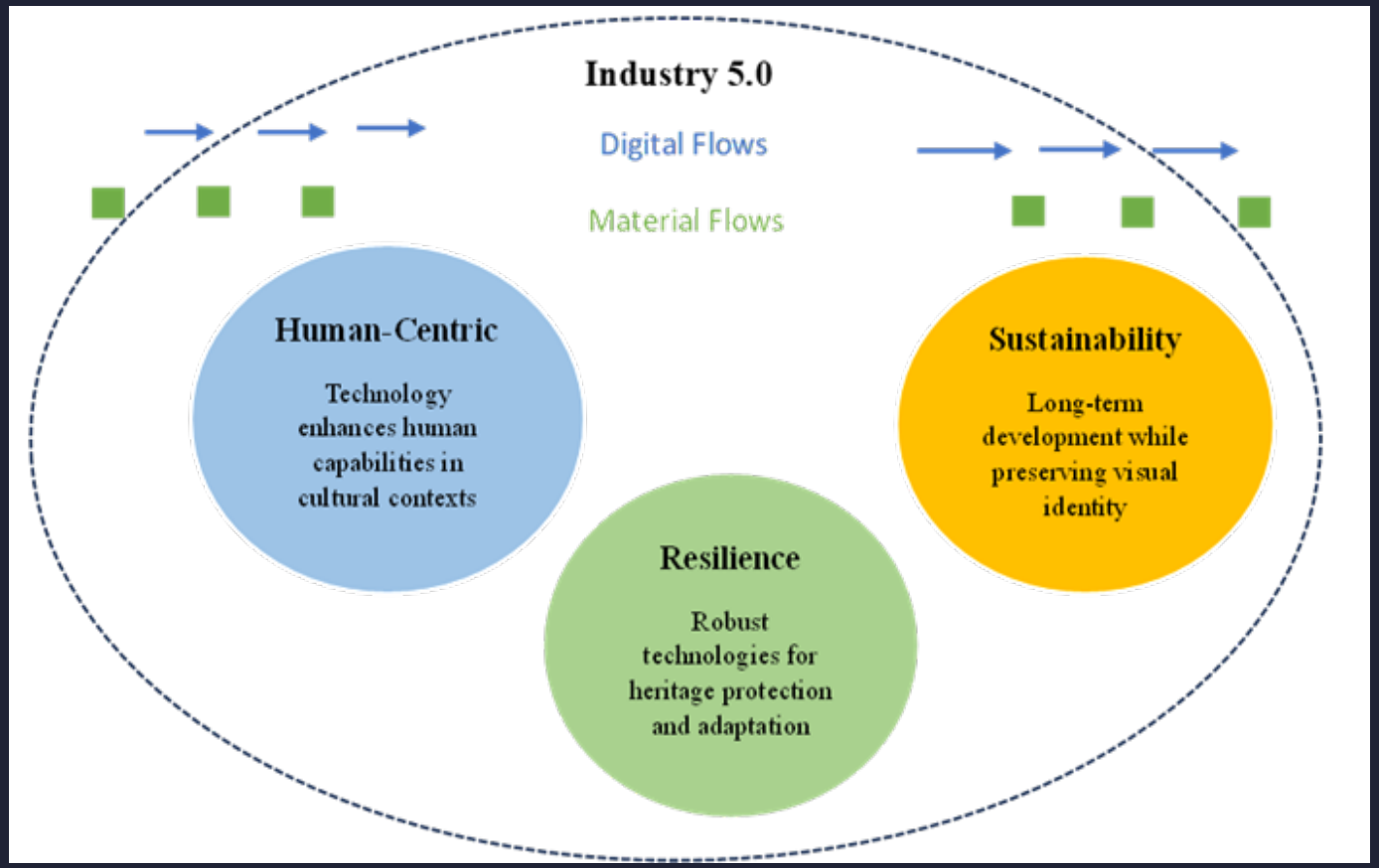
Theoretical framework



Research Gap

Conceptual Gap

Insufficient understanding of how digital flows interact with and influence traditional material flows, particularly in sensitive historical environments

Methodological Gap

Absence of standardized approaches for measuring and analyzing digital flows in HSTs

Limited frameworks for evaluating cultural impacts of digital transformation

Research Questions

RQ1. How can digital flows be integrated into Urban Metabolism (UM) frameworks, conceptualized and measured within historical urban contexts?

RQ2. What specific challenges and opportunities arise when integrating digital technologies into HSTs?

RQ3. How can Industry 5.0 paradigm guide implementation of digital solutions that respect heritage values?

Research Methodology

Integrated Methodological Approach:
Strategic Environmental Assessment (SEA)

- Environmental Integration: Impact of digital infrastructure on historical fabric
- Governance Alignment: Coordination between local, regional, and national initiatives
- Stakeholder Engagement: Structured consultation with community participation

DPSIR Framework Adaptation

Drivers: Smart city initiatives, heritage preservation imperatives
Pressures: Demands on infrastructure, resources, and social systems
State: Current condition of digital infrastructure and data flows
Impacts: Effects on historical fabric, resource efficiency, community dynamics
Responses: Policy formulations, capacity building, technical solutions

Research Methodology

Data Collection Methods

Quantitative: Digital infrastructure mapping, resource consumption metrics, usage analytics

Qualitative: Stakeholder interviews (n=18), expert consultations (n=7), observational studies

Documentary analysis: Technical documentation, policy documents, historical records

Results and Discussion: Digital Transformation in Taurasi

Digital Infrastructure Support Layers

Core Network Infrastructure: Wireless technology with reduced ecological footprint, IoT sensors

Data Collection Systems: Environmental monitoring networks, heritage preservation sensors

Service Delivery Infrastructure: Digital tourist information systems, e-government platforms

Digital Flows Analysis

Environmental Monitoring Flows: Real-time data on air quality, energy consumption

Cultural Heritage Flows: Digital documentation of historical assets, visitor movements

Transmission Flows: E-services usage, resource allocation data

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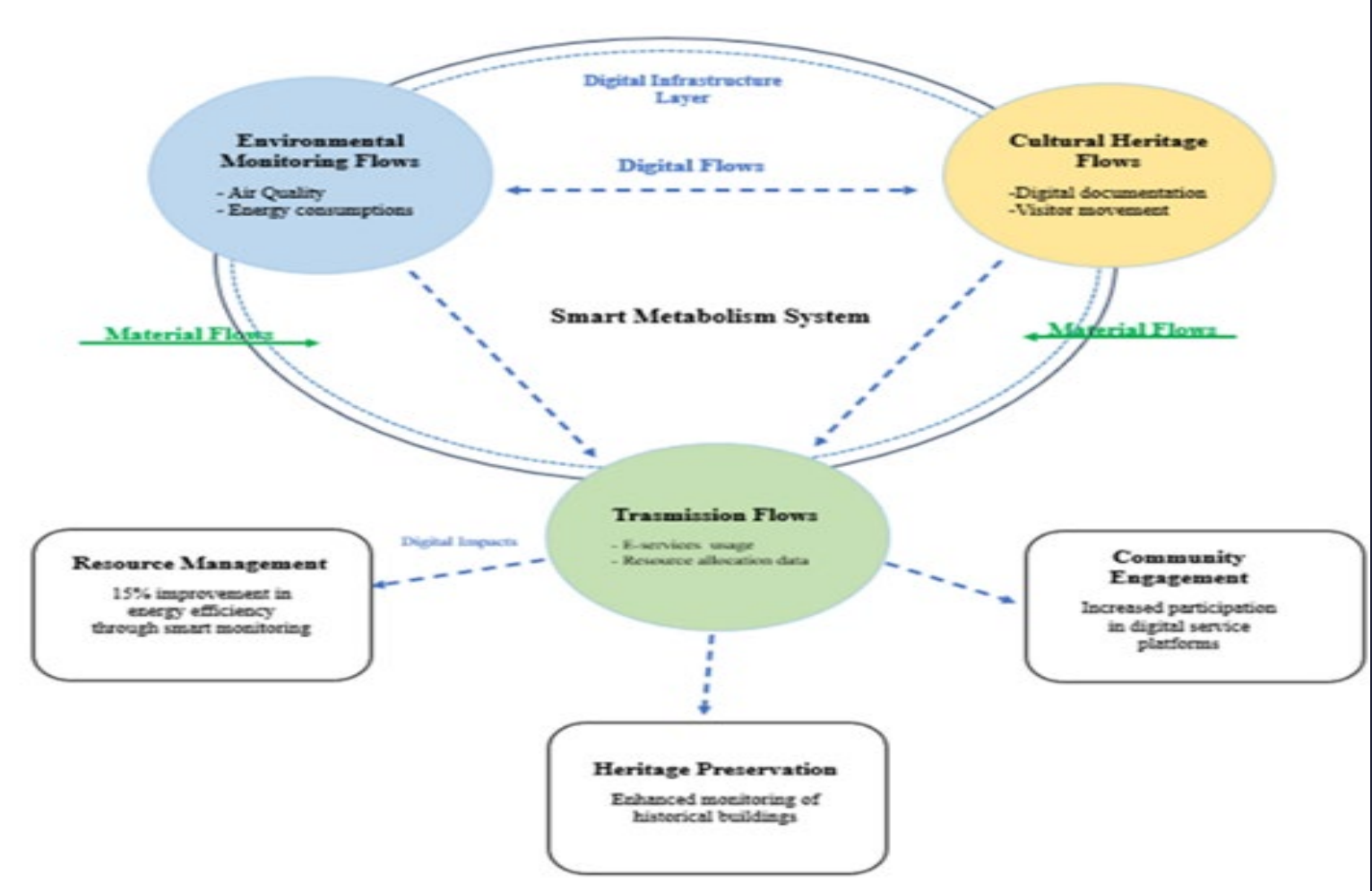

"Smart Metabolism" System

- Integration of digital flows with traditional material flows (Ioppolo et al., 2019)
- Embedded technologies enhancing resource efficiency while maintaining heritage preservation
- HST as dynamic ecosystem requiring collaborative stakeholder efforts

Measurable Impacts

Resource Management: 15% improvement in energy efficiency through monitoring systems

Heritage Preservation: more accurate building monitoring through sensor networks

Community Engagement: increased participation in digital service platforms

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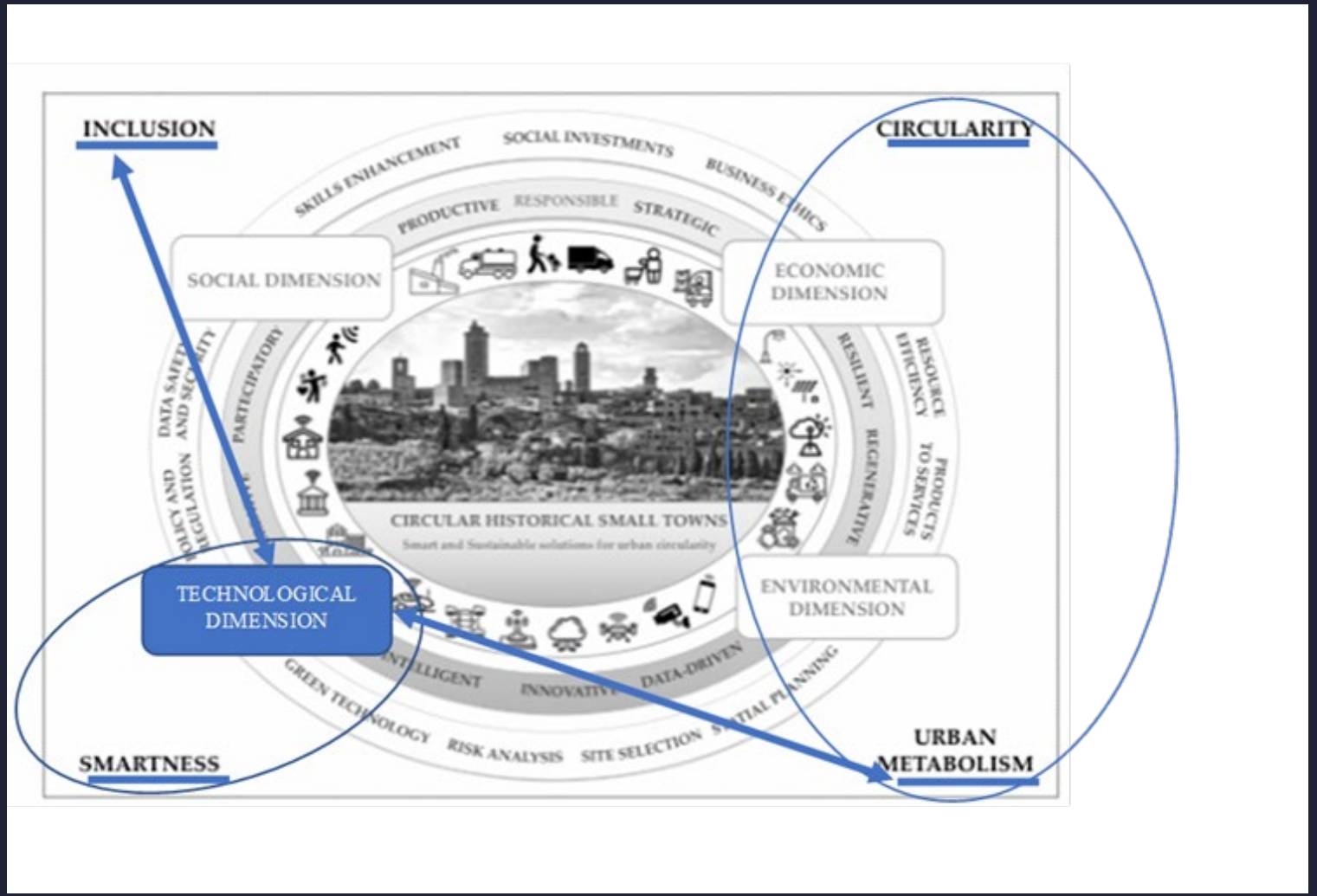

Theoretical and Practical Implications

- Extended Li et al.'s (2019) framework with empirical case study application
- Advanced "smart metabolism" concept (Ioppolo et al., 2019) with case-specific examples
- Demonstrated harmonious interaction between digital and traditional material flows

Three-Stage Implementation Approach

- Preliminary mapping of cultural and architectural characteristics
- Continuous engagement of local communities in decision-making
- Establishment of integrated monitoring systems for longitudinal assessment

Conclusion

The Taurasi case demonstrates that successful transformation requires careful balancing of preservation and innovation, supported by appropriate technologi-cal solutions and comprehensive stakeholder involvement. The integration of digital flows into MFA offers a robust model for understanding and managing this transformation.

- Develop specific digital transformation strategies aligned with heritage considerations
- Implement heritage-sensitive digital initiatives with community support
- Leverage digital monitoring for precise planning and efficient resource utilization

Limitations and Future Research

- Single case study design limits generalizability across diverse historical contexts
- Short-term evaluation period constrains assessment of long-term impacts
- Technological evolution may outpace methodological frameworks
- Resource constraints affecting comprehensive implementation of digital solutions

Future Research Directions

- Emerging technologies for simultaneous heritage protection and environmental impact reduction
- Longitudinal studies tracking long-term impacts of digital transformation
- Comparative analyses across multiple HSTs to identify context-specific success factors

Contact information

Thank you for your attention!

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