The HuT

Replication Roadmap

Deliverable D5.5

DEVELOPED WITHIN
WP5 Transferability and Scalability
T5.3 Replication Roadmap

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1. Technical references

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PP = Restricted to other programme participants (including the Commission Services)

RE = Restricted to a group specified by the consortium (including the Commission Services)

CO = Confidential, only for members of the consortium (including the Commission Services)

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1.1. Document history

Version	Date	Lead contributor	Description
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3. Introduction

3.1. Purpose and scope of the deliverable

Deliverable D5.5 “Replication Roadmap” provides a strategic and analytical synthesis of the amplification and replication processes emerging across The HuT demonstrators. The deliverable builds upon the conceptual and methodological foundations established in previous WP5 activities and integrates evidence generated through demonstrator exchanges, field visits, governance analyses, monitoring activities, and operational experimentation conducted across the project.

The roadmap aims to identify how Disaster Risk Reduction (DRR) solutions, approaches, governance practices, and stakeholder engagement mechanisms can be amplified, adapted, transferred, and replicated across different geographical, institutional, and hazard contexts.

The deliverable does not aim to reproduce detailed demonstrator descriptions or individual replication case documentation. Instead, it extracts cross-cutting patterns, amplification dynamics, enabling conditions, barriers, and replication pathways emerging from the collective demonstrator experience.

Detailed Replication Case Files and Cluster Synthesis Notes are provided in Annexes to this deliverable and constitute the empirical basis supporting the analytical findings and roadmap presented herein.

3.2. Position of D5.5 within The HuT project

D5.5 constitutes the strategic synthesis deliverable of WP5 and consolidates lessons emerging from amplification monitoring, demonstrator exchanges, governance analyses, field visits, and operational experimentation conducted throughout The HuT project.

While previous deliverables focused on documenting demonstrator activities, analysing governance dimensions, monitoring amplification processes, or capturing replication experiences, D5.5 aims to translate these findings into a forward-looking replication roadmap.

The roadmap therefore acts as an integrative layer connecting conceptual amplification work, demonstrator operational experiences, governance and policy analyses, field-based peer learning, replication observations, and strategic recommendations for future amplification pathways. The Replication Case Files and Cluster Synthesis Notes included as Annexes provide the empirical evidence underpinning the analytical findings presented in this roadmap.

3.3. Amplification and replication terminology

Within Deliverable D5.5, the term “Replication Roadmap” is used as the operational and communicative designation for the broader amplification-oriented framework developed throughout WP5.

While Deliverable D5.1 conceptualised replication as one subprocess within wider amplification dynamics, the implementation of WP5 demonstrated that processes of transferability, adaptation, recombination, iterative learning, governance evolution, and systemic scaling became deeply interconnected and analytically inseparable in practice.

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Consequently, within the context of D5.5, the term “Replication” is used in an expanded sense that encompasses the broader amplification ecosystem emerging across The HuT demonstrators. **The Replication Roadmap** should therefore be interpreted as functionally **equivalent to an amplification roadmap** grounded in the Amplification Framework established in D5.1 and operationalised through D5.2.

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4. Methodological approach

4.1. Evidence base

The Replication Roadmap was developed through the integration and synthesis of multiple evidence streams generated during the implementation of The HuT project.

The main sources informing the roadmap include:

- D5.1 amplification framework;
- D5.2 amplification monitoring methodology and collected data;
- Replication Case Files prepared for individual demonstrators;
- Cluster Synthesis Notes identifying thematic and cross-case replication patterns;
- D5.4 findings from physical and virtual field visits;
- governance and policy analyses from WP3 deliverables;
- demonstrator logbooks documenting operational evolution and amplification dynamics;
- internal demonstrator feedback regarding transferability, barriers, and amplification opportunities.

The roadmap therefore represents an integrative synthesis of conceptual, operational, governance, and experiential knowledge generated throughout the project.

Table 1: Evidence streams and analytical inputs supporting the development of the D5.5 Replication Roadmap.

Evidence Stream / Activity	**Related Tasks**	**Main Deliverables / Sources**	**Contribution to D5.5**
Amplification monitoring activities	T5.1, T5.3	D5.1, D5.2, DEM logbooks, amplification monitoring templates	Tracking amplification dynamics, barriers, enablers, operational evolution
Demonstrator exchanges and I-DRRnF workshops	T5.2	D5.3, D5.7, D5.8	Cross-demonstrator learning, replication observations, peer-learning evidence
Physical and virtual field visits	T5.2	D5.4	Transferability observations, operational comparison, interaction-driven learning
Replication Case Files	T5.3	Annex materials supporting D5.5	DEM-level analytical consolidation of amplification and replication processes
Cluster Synthesis Notes	T5.3	Annex materials supporting D5.5	Cross-case abstraction, thematic clustering, replication archetypes

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Governance and policy analyses	WP3 (especially T3.1–T3.3)	D3.1, D3.3, D3.4, D3.7	Governance barriers/enablers, institutional readiness, NbS and financing insights
Demonstrator operational experimentation	WP1, WP4	D1.1, D1.7, D4.3, D4.6	Operational learning, testing environments, technical and governance adaptation evidence
Stakeholder interaction and co-creation processes	WP1, WP2, WP5	D1.2, D1.5, D2.4, workshop activities	Participation dynamics, stakeholder ownership, communication and co-creation evidence
Strategic synthesis and abstraction	T5.3	D5.5	Development of amplification pathways, readiness framework, roadmap, and recommendations

4.2. Analytical approach

The analytical approach adopted in D5.5 was designed to move beyond isolated demonstrator assessment toward identification of broader amplification dynamics emerging across The HuT ecosystem. Rather than evaluating demonstrators individually, the analysis focused on cross-case comparison, thematic clustering, and abstraction of recurring operational and governance patterns observable across different territorial and hazard contexts.

Particular attention was paid to identifying how amplification processes evolved through interaction, adaptation, reinterpretation, and iterative learning between demonstrators. This allowed the analysis to move beyond simple transferability assessment toward examination of the systemic conditions shaping amplification readiness, replication pathways, and long-term operational sustainability.

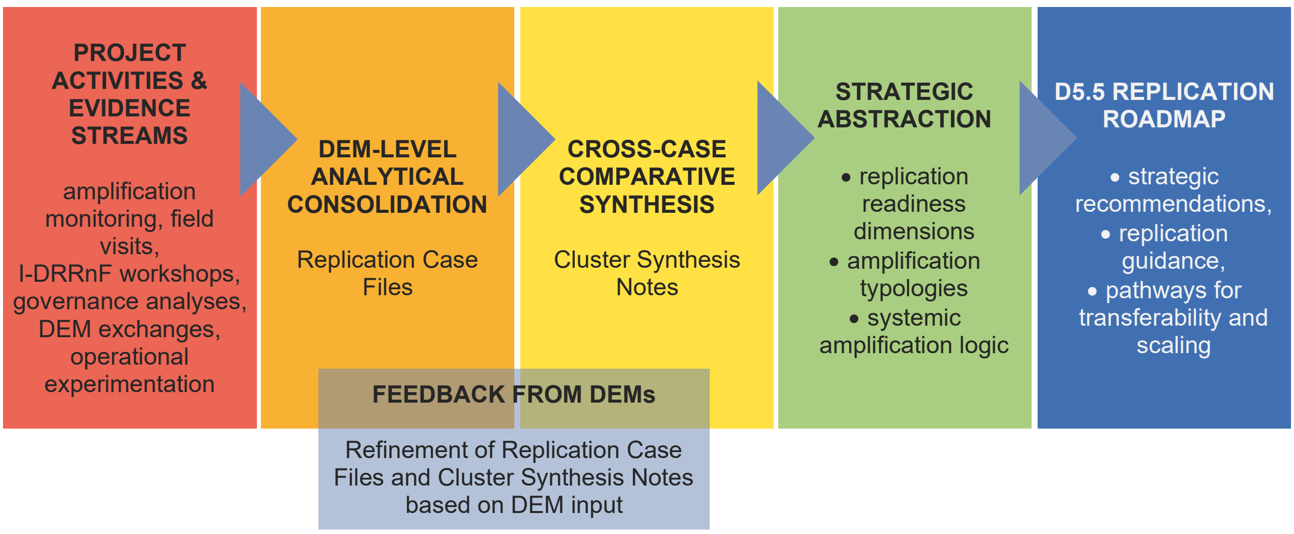

Figure 1: Analytical workflow underpinning the development of the D5.5 Replication Roadmap.

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Instead of focusing exclusively on transfer of individual solutions, the analysis concentrated on transferable operational principles, governance configurations, stakeholder engagement mechanisms, financing conditions, and institutional capacities influencing amplification processes across contexts.

The methodological synthesis further revealed evidence of second-order amplification dynamics, where demonstrators not only adopted approaches from one another but also recombined, adapted, and operationally transformed ideas emerging through demonstrator interaction and comparative reflection.

4.3. Role of field visits and demonstrator exchanges

Field visits and demonstrator exchanges constituted one of the most important mechanisms supporting amplification processes within The HuT.

Rather than functioning exclusively as dissemination activities, physical and virtual field visits created structured peer-learning environments where demonstrators could:

- compare operational practices and implementation experiences;
- discuss barriers and enabling conditions;
- evaluate transferability potential;
- identify adaptable components;
- exchange governance and stakeholder engagement approaches;
- test assumptions regarding replication across contexts.

The field visits also revealed that amplification is strongly interaction-driven. In many cases, demonstrators identified replication opportunities only after direct discussion with peers and exposure to operational realities in other contexts.

Evidence collected through the field visits demonstrated that demonstrators rarely attempted direct transfer of complete systems. Instead, exchanges typically focused on selected operational principles, governance arrangements, monitoring approaches, or stakeholder engagement mechanisms.

The exchanges further contributed to the emergence of second-order amplification processes, where demonstrators not only transferred ideas but also recombined and reinterpreted approaches originating from multiple demonstrators.

The Cluster Synthesis Notes indicate that these interaction-driven learning processes were particularly visible within governance-oriented and monitoring-oriented demonstrators, where operational practices evolved iteratively through peer exchange and comparative reflection.

Consequently, field visits played three interconnected roles within the roadmap development process:

1. generating empirical evidence regarding transferability;
2. stimulating cross-demonstrator learning and amplification;
3. validating the practical relevance of amplification pathways under real operational conditions.

The interaction-driven amplification processes observed during field visits were further reinforced through the I-DRRnF workshops and exchange activities documented in D5.3, which provided structured environments for peer-learning, operational comparison, and cross-demonstrator reflection.

4.4. Limitations

The roadmap reflects the state of demonstrator development and interactions during the project implementation period.

No formal external stakeholder validation process was conducted specifically for D5.5. However, many findings incorporated into this roadmap emerged from demonstrator interactions with stakeholders, field visits, workshops, governance analyses, and iterative demonstrator feedback processes.

The roadmap should therefore be understood as a dynamic synthesis of emerging amplification pathways rather than a prescriptive or exhaustive replication framework.

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5. Cross-Demonstrator analytical findings

The cross-demonstrator analysis revealed that amplification processes within The HuT evolved through complex interactions between governance structures, operational experimentation, stakeholder engagement, monitoring practices, and institutional adaptation.

Although demonstrators operated across highly diverse territorial, hazard, and governance contexts, several recurring amplification dynamics emerged consistently throughout the project. These dynamics frequently extended beyond direct transferability of individual solutions and instead reflected broader systemic patterns related to adaptation, recombination, modularity, iterative learning, and institutional embedding.

The following sections synthesise the principal analytical findings emerging from demonstrator exchanges, field visits, Replication Case Files, and Cluster Synthesis Notes, with particular attention to the mechanisms shaping amplification pathways across contexts.

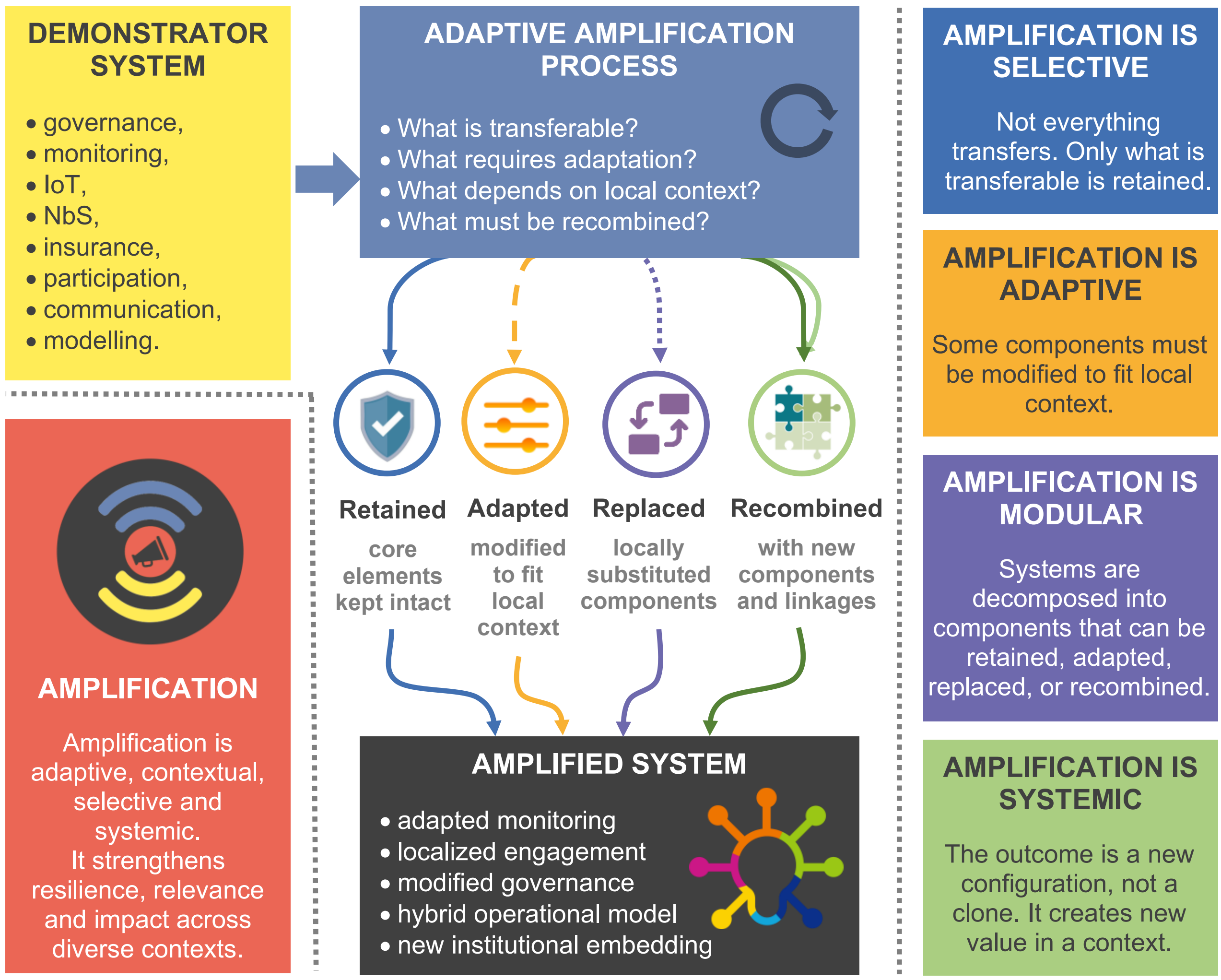

Figure 2: Replication as an adaptive amplification process

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5.1. Replication as abstraction rather than copying

One of the strongest findings emerging from the demonstrator exchanges is that replication rarely occurs through direct copying of solutions.

Across multiple demonstrators, solutions developed for specific hazards, institutional structures, or territorial conditions were considered valuable by other demonstrators not because they could be directly transferred, but because they embodied transferable principles.

Examples emerging from the field visits and demonstrator exchanges included:

- monitoring logics adapted across hazards;
- participatory governance approaches transferred between territorial contexts;
- communication strategies adapted to different stakeholder groups;
- decision-support mechanisms reinterpreted for alternative hazard scenarios.

This demonstrates that amplification within The HuT is primarily principle-based rather than solution-based.

Replication therefore emerges through abstraction, reinterpretation, and contextual adaptation.

5.2. System-level replication instead of tool transfer

Another recurring pattern concerns the systemic nature of replication.

Although demonstrators frequently exchanged information regarding tools, sensors, models, dashboards, or monitoring systems, the exchanges repeatedly revealed that these technical components only become meaningful when embedded within broader socio-technical systems.

Successful amplification depends on governance structures, institutional coordination, data-sharing mechanisms, operational procedures, communication channels, stakeholder trust, and decision-making integration.

As a result, replication within The HuT consistently evolved beyond technical transfer toward replication of integrated systems and operational ecosystems.

5.3. Cross-hazard transferability

The analysis revealed a strong tendency toward cross-hazard amplification.

Many demonstrators identified transferable elements in demonstrators addressing entirely different hazard profiles. Monitoring approaches developed for heatwaves inspired flood-related applications. Participatory wildfire management approaches informed discussions on flood governance and territorial coordination. Landslide monitoring approaches stimulated exchanges regarding urban resilience and warning systems.

This indicates that amplification pathways are frequently hazard-independent and instead rely on transferable governance, monitoring, communication, or decision-support principles.

The findings therefore suggest that transferability is often stronger across operational functions than across hazard categories.

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5.4. Institutional constraints as dominant barriers

One of the most consistent findings emerging across demonstrators was the mismatch between strong technical innovation capacity and comparatively weaker institutional readiness for long-term amplification.

While demonstrators generally succeeded in developing sophisticated monitoring systems, governance arrangements, communication tools, and operational approaches, amplification processes frequently encountered barriers linked to fragmented institutional responsibilities, unstable financing structures, limited coordination capacities, and insufficient long-term maintenance mechanisms.

Stakeholder engagement challenges and broader forms of organisational fragmentation further complicated efforts to sustain operational continuity beyond pilot or project environments. These patterns suggest that amplification capacity depends less on technological sophistication alone and more on the ability of governance systems to absorb, maintain, coordinate, and operationally embed innovation over time.

5.5. Modular replication logic

The demonstrator exchanges revealed that amplification processes rarely involved transfer of complete operational systems. Instead, replication typically occurred through selective decomposition and recombination of system elements that could be adapted independently across contexts.

In practice, demonstrators rarely attempted to reproduce entire governance or monitoring architectures. More commonly, they identified particular components such as:

- stakeholder engagement practices;
- communication approaches;
- modelling procedures;
- monitoring strategies;
- or financing arrangements that could be selectively integrated into different territorial and institutional environments.

This modular logic significantly increased transferability across diverse hazard and governance contexts because it allowed demonstrators to adapt individual operational elements without reproducing the full originating system.

5.6. Non-linear amplification dynamics

The amplification processes observed across The HuT do not follow a linear sequence from development to replication and scaling.

Instead, amplification emerged as a recursive and iterative process involving continuous feedback loops between:

- amplification within demonstrators;
- amplification out to other contexts;

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- amplification beyond toward governance and systemic influence.

In many cases, replication processes emerged before solutions reached full operational stabilisation, while external exchanges simultaneously contributed to improvement of the original demonstrator approaches. Governance learning frequently fed back into operational redesign, illustrating the recursive and co-evolutionary nature of amplification processes across demonstrators.

The amplification process therefore functioned as a dynamic system rather than a linear progression. Similar recursive learning dynamics were also documented through the later-stage demonstrator exchanges and workshop activities synthesised in D5.7 and D5.8, where operational reflection increasingly contributed to adaptation and redesign of existing approaches rather than only transfer of established practices.

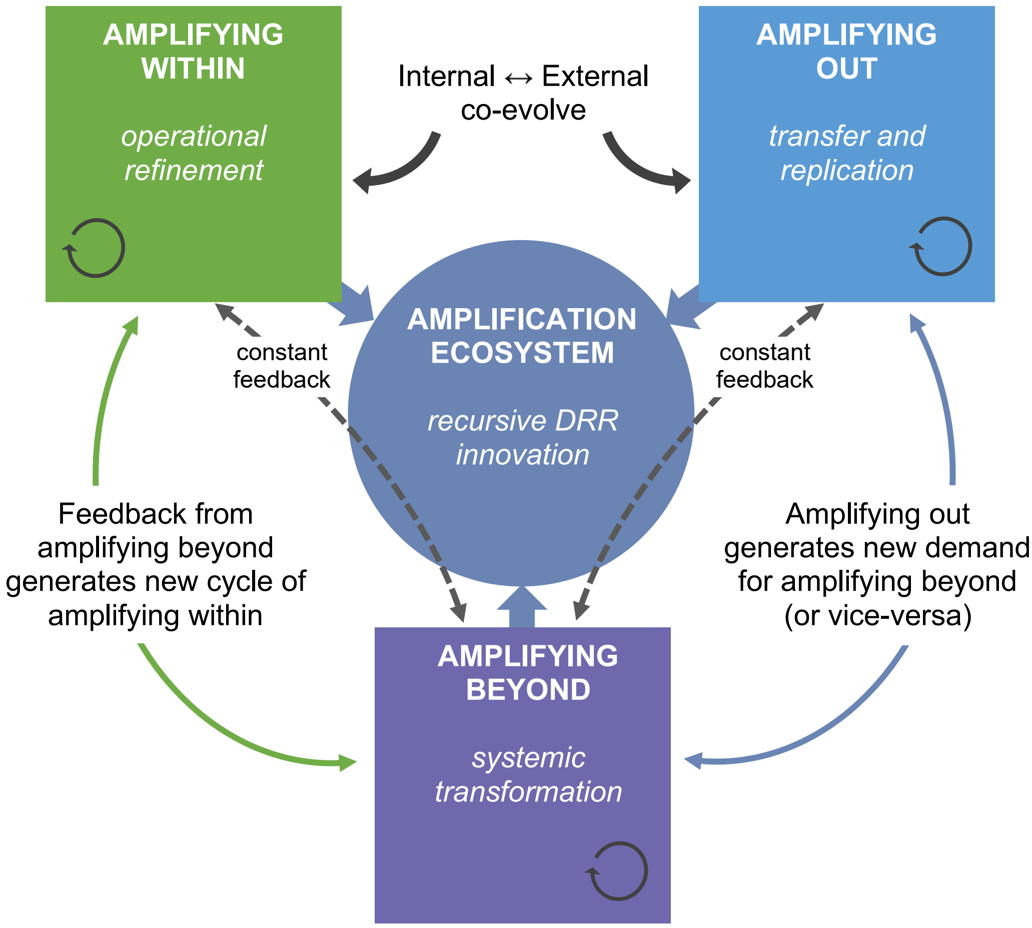

Figure 3: Non-linear amplification dynamics across demonstrator interactions.

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6. Typology of replication pathways

The analysis of demonstrator exchanges, Replication Case Files, and Cluster Synthesis Notes revealed that amplification processes followed multiple distinct but interconnected replication pathways.

Rather than representing fixed categories, these pathways frequently overlapped and evolved iteratively throughout demonstrator development. The typology presented below therefore serves as an analytical framework for understanding how amplification processes operated across different institutional, territorial, and hazard contexts.

6.1. Direct replication

Direct replication refers to the transfer of a solution or operational approach with limited contextual modification.

Within The HuT, direct replication appeared relatively rare due to the diversity of territorial, institutional, and hazard conditions represented across demonstrators.

Direct replication was primarily observed for:

- selected monitoring approaches;
- communication formats;
- operational procedures;
- transferable software components.

6.2. Adapted replication

Adapted replication emerged as the dominant amplification pathway.

In this process, demonstrators adopted selected principles or components while modifying them to fit:

- local governance conditions;
- hazard characteristics;
- stakeholder structures;
- operational capacities;
- available data;
- institutional constraints.

Adapted replication significantly increased the flexibility and resilience of amplification processes.

6.3. Cross-domain transfer

One particularly important observation emerging from demonstrator exchanges was that **amplification frequently occurred across hazard domains rather than within them**.

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Transferability was therefore often driven less by hazard similarity and more by the compatibility of operational logics, governance structures, and stakeholder interaction mechanisms.

Several demonstrators identified useful approaches in contexts substantially different from their own. Participatory wildfire governance informed discussions related to flood management, while landslide monitoring approaches stimulated reflection on urban resilience and warning systems. Similarly, monitoring strategies developed for heatwave contexts inspired exchanges related to flood-risk management and territorial coordination.

These interactions demonstrated that amplification pathways frequently emerge through reinterpretation of underlying operational principles rather than through direct transfer of hazard-specific solutions.

6.4. Internal amplification and iterative learning

Internal amplification refers to processes occurring within the consortium through demonstrator exchanges, field visits, collaborative discussions, and peer learning.

These internal amplification processes frequently generated:

- operational improvements;
- methodological refinement;
- stakeholder engagement innovations;
- governance adaptations.

Internal amplification therefore functioned as a learning ecosystem supporting wider replication potential.

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7. Enablers and barriers to amplification and replication

The demonstrator exchanges and Cluster Synthesis Notes revealed that amplification processes are shaped by recurring enabling conditions and barriers that extend across hazards and territorial contexts.

While demonstrators differed substantially in terms of governance systems, institutional capacities, territorial scales, and climate risks, remarkably similar amplification conditions emerged throughout the project.

The following sections synthesise the principal enabling and constraining factors influencing amplification readiness and long-term replication potential.

7.1. Governance and institutional enablers

Governance conditions consistently emerged as one of the strongest determinants of amplification readiness across demonstrators. In cases where institutional coordination, long-term planning structures, and cross-sectoral collaboration mechanisms were already well established, demonstrators generally showed greater capacity to sustain amplification processes beyond isolated pilot activities.

Particularly important enabling conditions included stable policy frameworks, formal stakeholder engagement structures, and integration of DRR considerations into territorial planning systems. These governance conditions not only facilitated operational implementation but also increased the ability of demonstrators to absorb iterative learning and maintain long-term institutional continuity during amplification processes.

7.2. Financial and economic enablers

The analyses conducted within WP3 highlighted the importance of financial mechanisms for supporting amplification processes. Dedicated funding instruments, risk financing approaches, insurance innovation, ecosystem-service valuation, and public-private partnerships all emerged as important enabling conditions influencing long-term sustainability and operational continuity. The work conducted on parametric insurance and innovative risk-transfer mechanisms further demonstrated that financial innovation may itself constitute an amplifiable governance pathway.

7.3. Technical and operational enablers

Technical readiness remained an important enabling factor.

Operational enablers included:

- interoperable data systems;
- accessible monitoring infrastructure;
- operational warning systems;
- modelling capacities;

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- user-oriented visualisation platforms;
- digital accessibility.

However, the analysis consistently showed that technical innovation alone is insufficient without institutional integration.

7.4. Social and participatory enablers

Stakeholder engagement emerged as a central enabling condition across demonstrators.

Key social enablers included:

- participatory governance;
- community engagement;
- educational activities;
- communication strategies;
- local ownership;
- stakeholder trust.

Many demonstrators highlighted that co-creation processes strengthened long-term ownership and increased the sustainability of amplification activities beyond initial implementation phases.

7.5. Recurring barriers across demonstrators

Despite substantial contextual diversity, remarkably similar barriers emerged across demonstrators.

Recurring barriers included:

- fragmented governance;
- path dependency;
- unstable financing;
- limited technical expertise;
- insufficient long-term maintenance;
- weak institutional coordination;
- stakeholder fatigue;
- organisational fragmentation.

The recurrence of these barriers suggests that amplification challenges are systemic rather than context-specific.

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8. Replication readiness framework

The findings emerging from demonstrator exchanges, field visits, governance analyses, and amplification monitoring activities indicate that successful amplification depends on more than transferability of individual solutions alone. Across demonstrators, long-term amplification capacity was shaped by combinations of technical maturity, governance conditions, stakeholder engagement, financial sustainability, and institutional continuity.

These observations suggest that replication readiness should be understood as a multidimensional and dynamic condition reflecting the broader capacity of demonstrator ecosystems to support amplification processes across contexts. The framework presented below therefore synthesises the principal dimensions influencing amplification readiness within The HuT.

8.1. Conceptualising replication readiness

The findings generated within The HuT indicate that replication readiness depends on multiple interacting dimensions.

Replication readiness should therefore not be understood exclusively as technological maturity but as the combined capacity of a demonstrator or solution ecosystem to support amplification and adaptation across contexts.

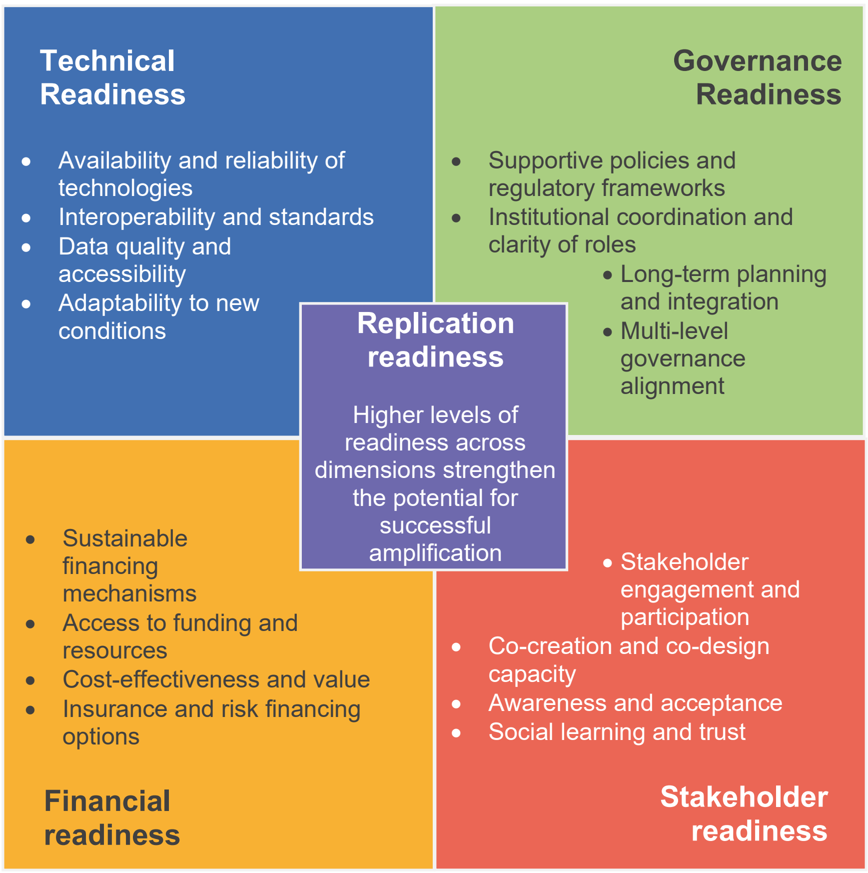

Figure 4: Conceptual dimensions of replication readiness within amplification processes.

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8.2. Dimensions of replication readiness

1. **Technical readiness** includes operational maturity of tools and systems, data availability, monitoring reliability, modelling robustness, and interoperability.
2. **Governance readiness** includes institutional coordination, policy integration, long-term planning, organisational stability, and cross-sectoral cooperation.
3. **Stakeholder readiness** includes community engagement, participatory structures, communication capacity, stakeholder ownership, and trust-building mechanisms.
4. **Financial readiness** includes sustainable financing mechanisms, maintenance capacity, risk-transfer instruments, and funding accessibility.

8.3. Dynamic readiness

The evidence suggests that replication readiness is dynamic rather than static.

Readiness evolves through:

- experimentation;
- field testing;
- operational learning ;
- stakeholder interaction;
- institutional embedding;
- iterative adaptation.

Replication readiness should therefore be treated as a developmental process.

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9. Replication Roadmap

The analytical findings emerging throughout D5.5 demonstrate that amplification processes evolve through iterative interaction between transferability, contextual adaptation, operational experimentation, governance embedding, and systemic learning. Rather than representing a linear replication sequence, amplification within The HuT developed through recursive and adaptive pathways shaped by demonstrator interaction and institutional evolution.

The Replication Roadmap presented below synthesises these findings into a strategic amplification-oriented framework describing how transferable DRR approaches can evolve across contexts while maintaining operational relevance and long-term sustainability. The roadmap should therefore be understood as a flexible and dynamic process model rather than a prescriptive implementation sequence.

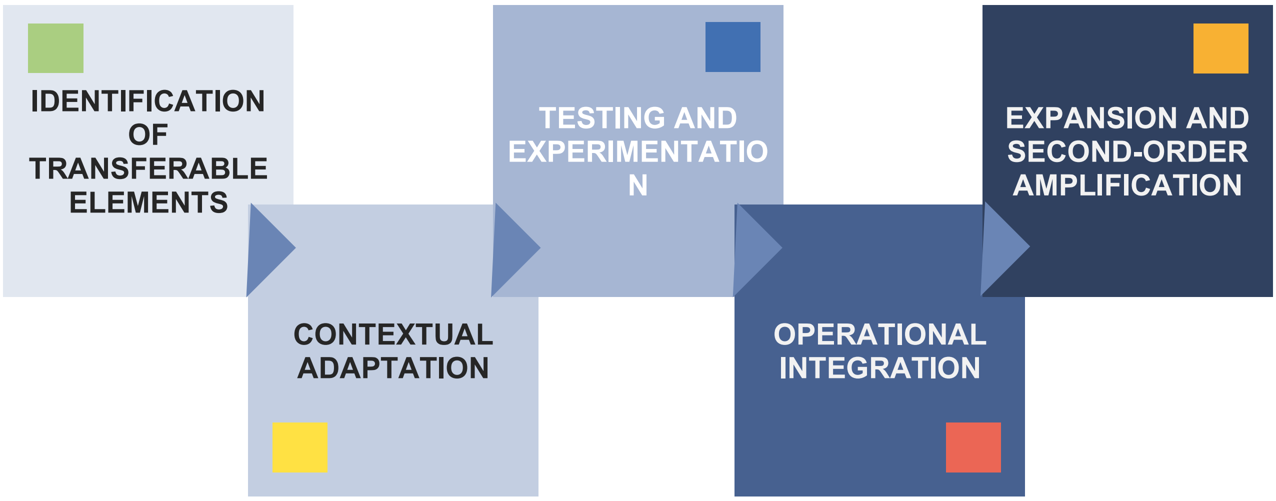

Figure 5: Phased replication roadmap for amplification of DRR solutions.

9.1. Phase 1 - Identification of transferable elements

The first phase of amplification involves identifying transferable principles, components, and operational mechanisms.

This phase requires:

- mapping operational practices;
- identifying transferable governance approaches;
- analysing contextual dependencies;
- distinguishing core and adaptable components.

The analysis conducted within The HuT demonstrates that **identifying transferable principles is more effective** than attempting direct replication of complete solutions.

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9.2. Phase 2 - Contextual adaptation

Contextual adaptation emerged as the central mechanism **enabling successful amplification** across The HuT demonstrators. Evidence collected through field visits and demonstrator exchanges consistently showed that transferable elements rarely functioned effectively without reinterpretation according to local governance structures, hazard conditions, institutional capacities, stakeholder configurations, and communication environments.

Consequently, amplification processes depended not on replication fidelity, but on the ability to adapt operational principles while preserving their functional relevance within different territorial contexts.

9.3. Phase 3 - Testing and experimentation

The third phase involves pilot implementation and experimental validation.

The project demonstrated the importance of:

- pilot sites;
- virtual field visits;
- demonstrator exchanges;
- iterative testing;
- experimental governance arrangements.

Testing environments reduce replication risks and support contextual learning. The operational experimentation activities conducted within WP4 further demonstrated that amplification readiness develops iteratively through testing environments where technical innovation, governance adaptation, and stakeholder interaction co-evolve under real operational conditions.

9.4. Phase 4 - Operational integration

Following successful testing, amplification requires operational integration into:

- institutional workflows;
- governance structures;
- operational decision-making;
- territorial planning;
- warning systems;
- communication structures.

Long-term sustainability depends not only on technical feasibility but also on successful institutional embedding and governance alignment capable of supporting continuous operation, maintenance, and adaptation.

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9.5. Phase 5 - Expansion and second-order amplification

The final phase involves wider amplification and systemic diffusion of approaches across contexts and governance environments. At this stage, amplification frequently evolves beyond direct transfer toward collaborative recombination, cross-domain adaptation, policy influence, governance transformation, and the emergence of new hybrid operational configurations.

The evidence generated throughout The HuT demonstrates that amplification increasingly becomes collaborative, recursive, and evolutionary over time, generating second-order amplification dynamics that extend beyond the original demonstrator environments.

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10. Strategic recommendations

The following recommendations translate the analytical findings and amplification pathways identified throughout this roadmap into strategic orientations supporting future amplification and replication processes.

The recommendations are intended to support the adaptation, transfer, sustainability, and long-term integration of DRR innovations across different territorial, institutional, and hazard contexts. They particularly aim to strengthen the enabling conditions required for amplification while addressing the recurring barriers identified across demonstrators.

Rather than proposing universal or prescriptive solutions, the recommendations provide guidance for improving the capacity of institutions, practitioners, communities, and innovation actors to support sustainable amplification processes.

The recommendations are particularly relevant for:

- actors supporting cross-regional learning and transferability;
- organisations coordinating multi-risk DRR strategies across scales;
- institutions involved in adaptation and contextualisation of DRR innovations;
- facilitators of participatory and co-development processes;
- actors contributing to long-term embedding and sustainability of DRR practices.

10.1. Governance and institutional recommendations

- Local and regional authorities should strengthen cross-sectoral coordination mechanisms connecting DRR, climate adaptation, territorial planning, and environmental governance.
- Policymakers should integrate amplification and transferability considerations into long-term territorial and climate adaptation strategies.
- Governance structures supporting DRR should promote stable institutional arrangements capable of sustaining long-term implementation, maintenance, and operational continuity.
- Public institutions should encourage collaborative governance approaches involving civil protection authorities, local communities, research institutions, and private actors.
- Authorities should support the creation of permanent exchange platforms and territorial learning mechanisms facilitating continuous cross-sectoral collaboration.
- Institutional actors should recognise that amplification requires adaptive governance structures capable of accommodating iterative learning and contextual adaptation.

10.2. Operational and technical recommendations

- Practitioners and demonstrators should prioritise modular and adaptable approaches rather than attempting direct replication of complete systems.
- Technical operators should strengthen interoperability between monitoring systems, modelling tools, communication platforms, and operational workflows.

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- Demonstrators should incorporate transferability considerations already during solution development and testing phases.
- Experimental and pilot environments should be further supported as spaces enabling contextual adaptation, iterative testing, and operational learning.
- Operational actors should strengthen integration between technical innovation and governance processes to ensure practical usability and institutional embedding.
- Future amplification activities should continue promoting cross-hazard exchanges, as many transferable mechanisms emerge across different risk domains.

10.3. Participation, communication and learning recommendations

- Stakeholder engagement should be integrated throughout amplification processes rather than treated as a separate dissemination activity.
- Practitioners and governance actors should strengthen participatory and co-creation mechanisms enabling local ownership and long-term sustainability.
- Communication strategies should be adapted to local risk perception, stakeholder capacities, and territorial contexts.
- Future projects should continue using field visits, demonstrator exchanges, and peer-learning activities as active amplification mechanisms.
- Research and innovation actors should further investigate how interaction-driven learning environments contribute to transferability and second-order amplification processes.
- Communities and local stakeholders should be recognised as active contributors to amplification processes rather than passive recipients of DRR innovations.

10.4. Financial and sustainability recommendations

- Public authorities and funding bodies should develop stable long-term financing mechanisms supporting implementation, maintenance, and adaptation of DRR solutions.
- Financial sustainability should be integrated into amplification planning from early development stages.
- Insurance innovation, parametric financing instruments, and ecosystem-service-based approaches should be further explored as amplification-supporting mechanisms.
- Funding programmes should support experimentation and contextual adaptation processes rather than focusing exclusively on large-scale deployment.
- Financing frameworks should recognise that amplification is iterative and often requires long-term institutional and operational support.
- Future DRR financing strategies should encourage integrated approaches combining technical, governance, ecological, and participatory dimensions.

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11. Conclusions

The Replication Roadmap demonstrates that amplification and replication within The HuT are dynamic, systemic, and interaction-driven processes.

Replication rarely occurs through direct transfer of complete solutions. Instead, demonstrators selectively reinterpret, adapt, and recombine transferable principles, governance mechanisms, monitoring approaches, and stakeholder engagement practices according to their territorial, institutional, and operational contexts.

The evidence generated through demonstrator exchanges, field visits, governance analyses, and operational experimentation highlights the importance of institutional coordination, stakeholder engagement, financial sustainability, iterative learning, and contextual adaptation as key enabling conditions supporting long-term amplification processes.

The roadmap further demonstrates that amplification processes are fundamentally non-linear. Internal learning, cross-demonstrator exchanges, governance evolution, and operational experimentation continuously interact and generate second-order amplification dynamics that reshape both originating and receiving contexts.

The HuT therefore demonstrates that amplification is not merely a process of scaling solutions, but a collaborative and evolving ecosystem of adaptation, interaction, learning, and systemic transformation. Rather than reproducing identical solutions across contexts, amplification within The HuT emerged through selective transferability, contextual reinterpretation, modular recombination, and iterative co-evolution between demonstrators and governance environments.

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Annex A: The HuT amplification framework and monitoring approach

The Replication Case Files and Cluster Synthesis Notes presented in this annex are based on the operationalized Amplification framework, composed of the two major pillars:

- the conceptual amplification framework developed in Deliverable D5.1, and
- the monitoring and documentation template established in Deliverable D5.2

This chapter therefore clarifies:

- how amplification is defined in The HuT,
- how amplification processes are monitored across demonstrators, and
- how replication potential is derived from documented amplification dynamics.

A.1. Conceptual Basis: The Amplification Framework

Deliverable D5.1 introduced the Amplification Framework as the conceptual backbone for analysing how Disaster Risk Reduction (DRR) solutions and innovations extend their impact beyond their initial development context.
The framework distinguishes three main amplification domains:

Amplifying Within

Extending or strengthening the impact of a solution within the original demonstrator context.
Subprocesses:

- *Stabilising* – reinforcing structures, linkages, and institutional embedding.
- *Speeding up* – accelerating uptake or implementation within the same context.

Amplifying Out

Expanding the geographical or contextual range of a solution.
Subprocesses include:

- *Growing*
- *Replicating*
- *Transferring*
- *Spreading*

Each of these reflects different degrees of contextual similarity between origin and receiving environments.

Amplifying Beyond

Transforming systemic conditions that enable or constrain the solution.
Subprocesses:

- *Scaling up* – embedding into policies, institutional frameworks or higher governance levels.
- *Scaling deep* – influencing values, perceptions, behavioural norms.
- *Scaling down* – ensuring implementation capacity at operational levels.

This conceptual architecture provides the interpretative lens for analysing demonstrator trajectories. It allows amplification to be understood not as a single linear process, but as a combination of stabilisation, expansion, and systemic transformation dynamics.
The present document applies this framework analytically without redefining it.

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A.2. Monitoring Architecture

Deliverable D5.2 translated the amplification framework into a structured monitoring system.
Its key operational elements are:

A.2.1. Amplifying Stories per Demonstrator

Each demonstrator defined a core innovation trajectory ("Amplifying Story") and its intended overarching outcome.

A.2.2. Interactions as the Unit of Analysis

Amplification is monitored through documented interactions, which may include:

- Technical developments
- Stakeholder engagements
- Governance exchanges
- Policy dialogues
- Field visits
- Knowledge transfer events

Each interaction represents a step in the amplification process and may generate tangible outputs.

A.2.3. Structured Reporting Mechanism

Amplification data is collected through:

- Logbooks completed by demonstrator leaders
- Structured questionnaires based on the D5.2 template
- The consolidated Excel monitoring dataset
- Supporting documentation (minutes, reports, exchanges)

A.2.4. Identification of Enablers and Barriers

For each interaction, demonstrators reflect on:

- Governance conditions
- Institutional arrangements
- Financial mechanisms
- Social acceptance factors
- Technical feasibility

This systematic monitoring ensures that amplification is not described narratively but traced empirically.
The Replication Case Files presented in this document draw directly on this monitoring system.

A.3. Through the different dimensions of the Amplification

Replication in WP5 is not treated as a standalone or abstract objective. It is analytically derived from observed amplification dynamics.
In this document:

- Amplification patterns are identified at demonstrator level.
- These patterns are compared across demonstrators.

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- Replication potential is extracted from recurring amplification mechanisms.

Replication is therefore conceptualised as:

A structured extension of amplification processes into new governance, geographical, or socio-technical contexts.

This approach avoids equating replication with simple copying. Instead, it identifies:

- Replicable elements (tools, processes, governance mechanisms),
- Necessary enabling conditions, and
- Transfer pathways grounded in documented interactions.

This logic directly prepares the analytical foundation for Deliverable D5.5 (Amplification Roadmap).

A.4. Role of the Present Document within WP5

Within the WP5 sequence:

- D5.1 established the conceptual amplification framework.
- D5.2 established the monitoring and documentation system
- The present Annex consolidates demonstrator-level amplification evidence into structured Replication Case Files and thematic Cluster Synthesis Notes.
- D5.5 will transform this structured evidence into a strategic Replication Roadmap.

This Annex therefore represents the methodological bridge between monitoring and roadmap development.

Its purpose is to:

1. Structure dispersed demonstrator evidence.
2. Identify amplification trajectories across contexts.
3. Extract cross-demonstrator replication patterns.
4. Provide an evidence-based foundation for amplification of demonstrator solutions.

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Annex B: Overview of demonstrators and replication case files

DEM profiles

DEM	DEM Lead Partner	Location (Site – Country)	Primary Hazards Addressed	Amplifying Story	Key Innovation	Main HuT Dimensions
DEM1	UPV	Valencia city – Spain	**Heatwaves, drought**	Supporting the climate-resilient governance	Urban climate maps for neighbourhood-level heat risk planning	Governance; Communities; Technology
DEM2	UPC	Val d’Aran region – Spain	**Floods, landslides, storms**	Supporting decision making with innovative EWS system	Integrated flood–landslide EWS with modelling and visualization platform	Early Warning Systems; Technology
DEM3	CMCC	Lattari Mountains – Italy	**Floods, landslides, storms**	Amplifying monitoring expertise and EWS solutions among the municipalities in Campania region	Serious game, IoT monitoring included in Platform for Decision Support and community engagement for landslide preparedness	Communities; Governance
DEM4	VU	Vilnius city – Lithuania	**Pluvial floods**	Supporting innovative flood disaster management and municipality governance	Social tolerance and participatory governance approaches to urban flooding	Governance; Communities
DEM5	HEREON	Schleswig-Holstein and harbour cities – Germany	**Heatwaves, storms, floods**	Science-art approach for citizen engagement and behavioural change	Science-art engagement and governance dialogue on climate adaptation	Governance; NbS
DEM6	IMO	East Fjords – Iceland	**Landslides, storms, avalanches**	Building platform for real time information and education	Landslide and avalanche monitoring integrated with community awareness tools	Early Warning Systems; Technology

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DEM7	KOTIVIZIG	Tisza River basin – Hungary	**Pluvial floods**	Stabilizing the VÍZ24 mobile application	IoT based risk assessment integrated to VÍZ24 mobile app.	Governance; Technology
DEM8	CMCC – CNR	Ogliastra former province – Italy	**Forest fires,**	Provide communities science-based fire mitigation approaches	Fire risk modelling combined with participatory planning and insurance mechanisms	Governance; Insurance
DEM9	BGS	Dorset county – United Kingdom	**Floods, landslides, storms**	Stabilizing the IoT technology	IoT-based monitoring for hazard forecasting and decision support	Technology; Early Warning
DEM10	UNIGE	Bern canton – Switzerland	**Floods, landslides, storms**	Nature-based solutions scaling-up within governance frameworks	Policy analysis and governance mechanisms supporting protection forests and NbS	Governance; NbS

The replication case files present a structured synthesis of amplification and replication processes observed across the HuT demonstrators. Each case file combines a general demonstrator profile, reflecting the intended design and thematic positioning of the demonstrator within the project, with an amplification profile that captures activities, interactions, and replication signals reported through WP5 monitoring. Drawing on demonstrator logbooks, amplification stories, and feedback, the case files focus on how solutions and practices have amplified within, beyond, and across local contexts, as well as on the barriers and enablers shaping their transferability. Together, the replication case files provide an evidence-based foundation for identifying realistic replication pathways and for informing the development of the Replication Roadmap.

DEM1

Demonstrator Profile

DEM1 addresses urban heatwaves and drought in a dense metropolitan environment where climate impacts directly affect vulnerable populations and essential services. The demonstrator combines climate monitoring, early warning systems, and community-facing engagement activities to support informed decision-making by river basin agencies and irrigation communities. Its activities focus on translating climate information into actionable knowledge at city level, highlighting the role of communication, trust, and institutional embedding. Replication relevance lies in mainstreaming heat risk management into everyday urban governance.

Amplification Profile

Amplification activities in DEM1 focused on translating heat-related climate information into accessible and actionable formats for river basin agencies and irrigation communities. Reported activities included public engagement formats, interactive tools, and experimentation with communication approaches aimed at increasing awareness and preparedness. Amplification occurred mainly within the city context, with emerging signals for amplifying out through transfer to other urban municipalities.

Dimension	Description
Hazard Context	Heatwaves, drought
Core Innovation	Online platform for droughts forecast and irrigation needs, supporting heat adaptation planning and governance under current and future climate conditions.
Amplification Domain	**Amplifying beyond**
Subprocess	**Scaling up + Scaling down**
Amplification Focus	Integrating climate risk information into planning frameworks and decision-making processes for urban heat management.
Amplification Mechanisms	Climate mapping, stakeholder engagement with planners, integration into governance processes.
Replication Relevance	Climate-proofed planning tools supporting heat adaptation strategies in urban environments.

Emerging Replication Opportunities

- **Transferring** approaches for integrating climate-risk information into municipal planning frameworks.
- **Spreading** communication and engagement practices that translate climate data into behavioral awareness and preparedness.

Key Replication Takeaways

Replicable Element	Enabling Conditions	Transfer Pathway
Online platform for droughts forecast	availability of meteorological data and drought forecast	adoption by irrigation communities, river basin agencies and water management bodies
Participatory communication tools for heat awareness	active municipal engagement structures; trusted communication channels	adoption through municipal climate adaptation programmes

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DEM2

Demonstrator Profile

DEM2 focuses on flood, landslide, and storm risks in a mountainous regional context characterised by complex terrain, rapid-onset hazards, and seasonal population dynamics. The demonstrator places strong emphasis on the evaluation of early warning systems and on understanding how different user groups perceive and respond to warnings. Its work provides insights into the challenges of operating EWS in areas with high uncertainty and diverse communication needs.

Amplification Profile

Reported amplification activities in DEM2 centred on the evaluation of early warning systems, including sensor deployment, modelling automation, and testing of communication practices. Education and outreach activities supported engagement with diverse user groups, while collaboration with emergency management actors enabled knowledge exchange beyond the region.

Dimension	**Description**
Hazard Context	Floods, landslides, storms
Core Innovation	Data portal and threshold-based decision-support tools improving early warning systems for mountain hazards.
Amplification Domain	**Amplifying beyond**
Subprocess	**Scaling down**
Amplification Focus	Standardising early warning procedures and supporting operational decision-making using improved data integration and visualization.
Amplification Mechanisms	Data portal development, modelling tools, operational engagement with first responders and administration.
Replication Relevance	Early warning decision-support frameworks transferable to other mountainous hazard regions.

Emerging Replication Opportunities

- **Replicating** integrated multi-hazard early warning system architectures in other mountainous or transboundary river basins.
- **Transferring** coordination practices supporting basin-wide disaster preparedness and response.

Key Replication Takeaways

Replicable Element	Enabling Conditions	Transfer Pathway
Integrated early warning decision-support tools	access to real-time hazard monitoring and modelling data; cooperation with authorities	deployment in mountainous or multi-hazard regions

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User-oriented evaluation methods for EWS	engagement of diverse stakeholder groups; institutional commitment to continuous evaluation	integration into national or regional warning system improvement programmes

DEM3

Demonstrator Profile

DEM3 operates in a Mediterranean multi-hazard context, addressing geo-hydrological perils induced by extreme precipitations but associated with specific geomorphological contexts: the pyroclastic covers produced by Somma-Vesuvius and Campi Flegrei volcanic centers mantle slopes of calcareous bedrock in small basins. The main events are flash floods and landslides, while, often, forest fires act as predisposing conditions removing the vegetation protection. The area has a strong tourism appeal, with a large number of visitors who, attracted by its natural beauty, are often not sufficiently aware of the risks or how these are communicated. Moreover, resources, such as municipal police, are typically allocated based on the resident population rather than the significantly increased population (now present for most of the year) due to tourist flows. In addition to technical early warning components improved by the adoption of IoT and community monitoring in areas poorly covered by the official networks and a platform to support the decision makers during the preparedness stages, the demonstrator experiments with innovative insurance solutions, serious games and science–art approaches to support preparedness, learning, and reflection among stakeholders and communities. These activities highlight the added value of creative and experiential methods in risk communication and capacity building. DEM3 illustrates how innovative engagement formats can complement conventional DRR tools.

Amplification Profile

Amplification evidence shows that DEM3 focused on maintaining interaction with local authorities and communities through participatory processes and information exchange. Two flagship towns have been identified in the area: Amalfi and Sorrento (this one beneficiary in the Consortium). Furthermore, the goal is that of enabling a simple and straight replication also in other Municipalities in the Lattari Mountains area. In this context, IoT monitoring has been carried out in both municipalities, and stakeholder meetings for the development of the insurance solution have also taken place. The game has been tested with high school students through several initiatives across the region. Science art initiatives, which will culminate in the Art and Science Festival in June in Naples, have also been replicated in Sorrento, where the municipality has organized a series of events for different age groups aimed at increasing awareness of weather induced hazards. Last but not least, the platform developed with the support of ARANTEC, now already available on the Play Store, is fully customizable and currently includes sensors from the Sorrento and Amalfi areas. Activities included the exploration of human-sentinel approaches and engagement formats aimed at supporting preparedness. Replication signals relate primarily to stakeholder engagement methods rather than to specific technical solutions.

Dimension	Description
Hazard Context	Extreme precipitation induced hazards

Core Innovation	Monitoring expertise and decision support tools for early warning solutions shared among municipalities in Campania. Increased awareness by using Science-Art initiatives and serious gaming
Amplification Domain	**Amplifying out**
Subprocess	**Growing + Transferring**
Amplification Focus	Expanding monitoring knowledge and preparedness practices across municipalities beyond the initial pilot sites.
Amplification Mechanisms	Knowledge exchange between municipalities, monitoring platforms, stakeholder engagement activities.
Replication Relevance	Transfer of monitoring practices and early warning expertise across regional DRR networks.

Emerging Replication Opportunities

- **Replicating** serious games and participatory engagement tools in other multi-hazard regions.
- **Spreading** science–art approaches for awareness raising.
- **Spreading** educational formats supporting community awareness of landslide risks.

Key Replication Takeaways

Replicable Element	Enabling Conditions	Transfer Pathway
Serious games for disaster preparedness	facilitation expertise; collaboration with local authorities and educational institutions	transfer through training programmes and educational initiatives
Participatory risk communication methods	stakeholder engagement structures; openness to collaborative learning formats	adoption by regional DRR networks and community preparedness programmes

DEM4

Demonstrator Profile

DEM4 addresses flood risk in an urban river basin, with a strong focus on participatory governance and local decision-support processes. The demonstrator explores how different actors interact in flood risk management and how inclusive governance arrangements influence the uptake and legitimacy of technical tools. Its experience underscores the importance of institutional trust, facilitation, and long-term engagement in replication.

Amplification Profile

WP5 monitoring indicates that amplification in DEM4 centred on participatory governance arrangements, including stakeholder forums and structured dialogue with municipal actors. The demonstrator generated learning on how governance processes influence the uptake of risk information and planning tools.

Dimension	Description
Hazard Context	Pluvial floods
Core Innovation	Climate-informed rainfall prediction tools supporting planning and infrastructure management decisions.
Amplification Domain	**Amplifying beyond**
Subprocess	**Scaling up + Scaling down**
Amplification Focus	Translating rainfall probability predictions into operational planning recommendations for municipal infrastructure.
Amplification Mechanisms	Climate modelling, stakeholder engagement with asset managers, decision-support integration.
Replication Relevance	Planning tools supporting climate-resilient urban flood management strategies.

Emerging Replication Opportunities

- **Transferring** participatory governance approaches for urban flood risk management to municipalities with similar institutional contexts.

Key Replication Takeaways

Replicable Element	Enabling Conditions	Transfer Pathway
Climate-informed rainfall prediction tools for planning	access to climate modelling expertise; collaboration with municipal infrastructure managers	transfer to cities integrating climate risk into urban planning
Participatory governance frameworks for flood risk	inclusive stakeholder forums; facilitation capacity	adoption through municipal flood risk governance initiatives

DEM5

Demonstrator Profile

DEM5 adopts a participatory approach to the development of measures aimed at reducing flood risk in coastal cities and their surrounding areas. In close collaboration with the affected population, local knowledge, experiences, and needs are systematically integrated into the research and planning process. The affected population includes decision-makers from municipal administrations, experts in the field of flood protection, as well as the broader local community.

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The objective is to jointly develop viable and sustainable solutions that address both the specific regional conditions and the requirements of effective flood risk management.

Amplification Profile

Reported amplification activities in DEM5 focused predominantly on cultural and participatory engagement formats, including the SAFE HAVEN exhibition, World Café events, and citizen dialogues. These activities aimed to stimulate reflection on climate risks and adaptation pathways rather than to implement physical NbS.

Dimension	Description
Hazard Context	Floods, storms, heatwaves
Core Innovation	Community-based climate adaptation narratives and awareness initiatives supporting risk preparedness.
Amplification Domain	**Amplifying beyond**
Subprocess	**Scaling deep**
Amplification Focus	Increasing risk awareness and community engagement around climate risks through participatory storytelling and cultural initiatives.
Amplification Mechanisms	Safe Haven exhibition, citizen dialogues, school engagement and climate storytelling.
Replication Relevance	Narrative-based engagement approaches supporting climate adaptation awareness in vulnerable communities.

Emerging Replication Opportunities

- **Spreading** science–art engagement approaches communicating climate risks and adaptation narratives to wider audiences.
- Application in cities seeking to combine flood protection with environmental co-benefits.

Key Replication Takeaways

Replicable Element	Enabling Conditions	Transfer Pathway
Climate storytelling and narrative-based engagement formats	collaboration with cultural institutions and educators	replication through exhibitions, public engagement programmes, and awareness campaigns
Community dialogue formats for climate adaptation	facilitation capacity; local stakeholder networks	integration into local climate adaptation planning processes

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DEM6

Demonstrator Profile

DEM6 deals with landslide and storm risks in a sparsely populated regional context, focusing on multi-hazard monitoring and warning systems operating at larger territorial scales. The demonstrator offers insights into replication in areas with limited local capacity, where national and regional coordination play a central role. Its experience highlights how scale and institutional arrangements shape replication pathways.

Amplification Profile

Amplification evidence indicates that DEM6 activities focused on stakeholder engagement around a newly developed platform and on coordination challenges related to timing and capacity. Rather than full system deployment, amplification centred on presenting tools and aligning expectations among institutional actors.

Dimension	Description
Hazard Context	Landslides, storms, avalanches
Core Innovation	Hazard information platform and improved landslide early warning capabilities for local communities.
Amplification Domain	**Amplifying beyond**
Subprocess	**Scaling up + Scaling deep**
Amplification Focus	Improving public access to hazard information and strengthening operational warning capabilities.
Amplification Mechanisms	Hazard information website, educational materials, collaboration on landslide forecasting tools.
Replication Relevance	Community-focused hazard information platforms supporting disaster preparedness in remote regions.

Emerging Replication Opportunities

- **Replicating** hazard monitoring and information platforms in other remote or hazard-prone regions where early warning capacity is developing.

Key Replication Takeaways

Replicable Element	Enabling Conditions	Transfer Pathway
Hazard information platforms for communities	access to hazard monitoring data; institutional responsibility for public communication	deployment in remote or sparsely populated hazard-prone regions

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Integrated monitoring–warning communication practices	coordination between scientific agencies and emergency authorities	adoption within national or regional disaster preparedness programmes

DEM7

Demonstrator Profile

DEM7 concentrates on flood risk management in a large river basin, emphasising coordination among multiple stakeholders and governance levels. The demonstrator addresses the challenges of aligning responsibilities, data, and decision-making across basin-wide systems. Its experience illustrates how governance mechanisms shape the feasibility and durability of replication.

Amplification Profile

Reported amplification activities in DEM7 emphasised coordination meetings, training activities, and engagement within basin-wide governance structures. Learning focused on the challenges of aligning actors and responsibilities across scales.

Dimension	Description
Hazard Context	Pluvial floods in urban area
Core Innovation	VíZ24 mobile application supporting municipalities during pluvial flood events through digital tools, in HuT project the application was improved with IoT based risk assessment
Amplification Domain	**Amplifying within**
Subprocess	**Stabilising**
Amplification Focus	Stabilising and improving the operational use of the VÍZ24 mobile application for municipal pluvial flood management.
Amplification Mechanisms	Application testing, operational refinement, collaboration with municipal authorities.
Replication Relevance	Digital pluvial flood management tools supporting municipal emergency response systems.

Emerging Replication Opportunities

- **Growing** operational use of the VÍZ24 mobile application among municipalities within different geographical conditions. We expand the application to two different geographical conditions municipalities in order to test it.

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Key Replication Takeaways

Replicable Element	Enabling Conditions	Transfer Pathway
ViZ24 pluvial flood management platform	municipal flood management responsibilities; technical capacity to operate digital systems	amplifying out through transfer to municipalities
Operational pluvial flood coordination practices	cooperation among authorities and local governments	adoption through municipalities, water directorates and civil protection networks

DEM8

Demonstrator Profile

DEM8 integrates climate-driven fire modelling with stakeholder knowledge and financial instruments to support fire risk management at local scale. The demonstrator explore how co-designing land management scenarios under current and future conditions can provide the scientific and knowledge base necessary to help policy and decision makers define effective adaptation and mitigation strategies for fire prevention. Its work highlights the importance of regulatory context and evidence in enabling replication.

Amplification Profile

Amplification data show that DEM8 activities concentrated on participatory mapping, community engagement, and the integration of risk information for fire-smart practices. While links to financial and insurance mechanisms are discussed, they remain exploratory.

Dimension	Description
Hazard Context	Forest fires, drought, heatwaves
Core Innovation	Fire-risk modelling linked with insurance incentives promoting prevention and community preparedness.
Amplification Domain	**Amplifying beyond**
Subprocess	**Scaling up + Scaling deep**
Amplification Focus	Integrating fire risk modelling, community engagement and financial incentives for wildfire risk reduction.
Amplification Mechanisms	Stakeholder co-creation processes, modelling tools, insurance product development.
Replication Relevance	Development of a modelling process that integrates, at local level, science-based fire risk modelling with stakeholders knowledge, policies and governance

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Emerging Replication Opportunities

- **Transferring** concepts linking wildfire risk modelling with stakeholders' knowledge, policies and governance and financial incentives for prevention to regions with similar regulatory frameworks.
- **Replicating** wildfire risk modelling tools supporting stakeholder knowledge-based prevention strategies.

Key Replication Takeaways

Replicable Element	Enabling Conditions	Transfer Pathway
Fire-risk modelling linked with stakeholders knowledge	availability of hazard modelling expertise; active engagement of collaborative stakeholders; establishment of trust-based relationships through co-design processes, and continuous knowledge exchange to ensure mutual understanding and uptake of modelling outputs.	adaptation to fire-prone regions exploring prevention-oriented policies
Insurance-supported wildfire risk reduction concepts	supportive regulatory framework; engagement of insurance sector	implementation through public–private partnerships

DEM9

Demonstrator Profile

DEM9 is supporting stakeholders in their drive to make Dorset more resilient by reviewing data access and needs. The aim is to build a culture of collaboration and cooperation between Dorset stakeholders including local authorities and scientific experts. There needs to be a better understanding of how data, information and tools from key organisations are currently accessed and used in decision making, and how this can be supported by the organisations that are providing them. One of the key issues is coastal landslides in a location famous for its tourism. The demonstrator is exploring how technology and data could support scientific understanding of landslide events to support informed decision-making and communication.

Using IoT-based environmental monitoring technologies improve hazard detection and modelling. explore the use of IoT sensors in harsh coastal environments to provide useful, usable and used information to, primarily, local authorities responsible for managing coastal footpaths and public access to the DEM. However, engagement with a range of stakeholders brought insight into this activity beyond local authorities.

Amplification Profile

Reported amplification activities in DEM9 focused strongly on technological monitoring, including the deployment of IoT sensors, data platforms, and the drive for warning communication tools. Engagement with local authorities supported testing and refinement of these technologies.

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Dimension	Description
Hazard Context	Floods, **landslides**, storms
Core Innovation	IoT-based environmental monitoring technologies improving hazard detection and modelling.
Amplification Domain	**Amplifying within**
Subprocess	**Stabilising**
Amplification Focus	Stabilising and refining IoT monitoring technologies and improving their operational use.
Amplification Mechanisms	Sensor deployment, hazard modelling improvements, stakeholder testing.
Replication Relevance	IoT monitoring technologies supporting hazard monitoring systems in other regions.

Emerging Replication Opportunities

- **Replicating** IoT-based monitoring technologies for hazard detection and forecasting in other regions with comparable monitoring needs.
- Alignment with regional climate adaptation strategies.

Key Replication Takeaways

Replicable Element	Enabling Conditions	Transfer Pathway
IoT-based environmental monitoring technologies	sensor infrastructure; technical maintenance capacity	deployment in regions developing digital hazard monitoring networks
Data-driven hazard monitoring practices	integration with local decision-making structures	adoption through regional climate adaptation or DRR strategies

DEM10

Demonstrator Profile

DEM10 develops risk modelling concepts as well as analyses of nature-based solutions applications with relevance beyond the local scale. The demonstrator contributes primarily at the methodological and policy levels, supporting evidence-based decision-making by regulators and public authorities. Its role in replication is linked to analytical frameworks rather than direct local implementation.

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Amplification Profile

Amplification evidence shows that DEM10 focused on qualitative research, including interviews, stakeholder focus groups, publications, and analysis of governance barriers and enablers related to NbS and risk management. Its contribution to replication lies primarily in evidence-building and policy-relevant insights on protection forest management.

Dimension	Description
Hazard Context	Floods, landslides, storms
Core Innovation	Nature-based solutions governance and policy frameworks supporting DRR strategies, weather measurement and risk modelling.
Amplification Domain	**Amplifying within**
Subprocess	**Stabilising + Speeding up**
Amplification Focus	Strengthening governance frameworks and accelerating adoption of nature-based solutions.
Amplification Mechanisms	Policy analysis, stakeholder engagement, governance recommendations.
Replication Relevance	Governance frameworks enabling broader adoption of NbS for disaster risk reduction.

Emerging Replication Opportunities

- Replication opportunity through policy dialogue and advisory processes.
- **Spreading** governance approaches supporting the integration of protection forests and other nature-based solutions into regional risk management frameworks.
- Use of outputs by insurance professionals and regulatory bodies.

Key Replication Takeaways

Replicable Element	Enabling Conditions	Transfer Pathway
Governance frameworks supporting NbS adoption	existing supportive policies and legal frameworks, growing funding opportunities or financial support, municipal commitment, and interdisciplinary expertise growing scientific evidence in NbS performance and co-benefits	transfer through policy dialogue and advisory processes
Analytical methods for assessing DRR governance barriers	availability of policy analysis expertise	adoption by regional authorities and international DRR initiatives

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Annex C: Cluster synthesis notes

C.1. Thematic clusters across demonstrators

The cluster synthesis table summarises cross-demonstrator insights by grouping The HuT activities into four thematic clusters reflecting dominant solution types and replication logics. The synthesis draws on the replication case files and amplification profiles, and focuses on observed replication pathways, synergies, and enabling or constraining conditions rather than on intended demonstrator roles. The clusters provide an analytical lens to compare heterogeneous experiences across demonstrators and to identify common patterns that inform the Replication Roadmap.

Cluster synthesis

Dimension	Nature-based Solutions (NbS)	Early Warning Systems & Technology	Insurance & Finance	Governance & Communities
Shared Replication Pathways	• NbS replication typically follows a **within → beyond trajectory**, where local pilots first stabilise governance arrangements and later influence planning frameworks and adaptation strategies. • Replication depends strongly on **institutional embedding in spatial planning, environmental policy, and local adaptation strategies**. • Scaling processes are often gradual because NbS require alignment between ecological processes, land management, and governance structures.	• Replication of EWS and technological solutions commonly follows **within and out pathways**, where systems are first stabilised within demonstrators and then transferred to comparable contexts. • Modular technological components (monitoring, modelling, communication platforms) enable adaptation to different hazard environments. • Broader impacts emerge when systems become connected to **regional or national warning infrastructures.**	• Financial and insurance innovations tend to amplify mainly **beyond the demonstrator scale**, because implementation requires engagement with insurers, regulators, and financial actors. • Demonstrators serve primarily as **testing environments for modelling, risk assessment, and incentive mechanisms.** • Replication pathways are therefore mediated through **policy dialogue, regulatory frameworks, and public–private partnerships**.	• Governance and community-oriented innovations amplify mainly **within and beyond**. • Within pathways involve **deep institutional embedding and trust-building among stakeholders**, while beyond pathways occur when governance practices influence wider policy debates or institutional reforms. • Replication is rarely direct; instead, it occurs through **social learning, peer exchange, and institutional adaptation**.

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Key Synergies Across DEMs	• DEM1, DEM8, and DEM10 investigate how NbS can help addressing different risks such as heatwaves, wildfires, floods and landslides while delivering ecosystem services and biodiversity benefits. • These demonstrators highlight synergies between **risk reduction, landscape management, and governance** arrangements.	• DEM1, DEM2, DEM6, and DEM9 demonstrate complementarities between **monitoring systems, hazard modelling, and warning communication**. • DEM4 and DEM7 show how EWS outputs can support **local decision-making and preparedness planning**.	• DEM3 and DEM8 connect **risk modelling and hazard assessment with the exploration of innovative insurance mechanisms**. • DEM8 particularly demonstrates how financial incentives can support **preventive risk reduction measures at community level**.	• DEM4 and DEM7 illustrate how participatory governance structures strengthen **local flood risk management and preparedness planning**. • DEM8 integrates **stakeholder engagement and co-design processes into fire risk modelling,** ensuring that the mitigating solutions are grounded in real-world needs, acceptable to stakeholders, and feasible for implementation. • Science–art and narrative activities in DEM1, DEM3, and DEM5 contribute to reshaping **risk perception and community engagement**, creating additional pathways for replication.
Key Enablers & Barriers	Research conducted in DEM1, DEM8, and DEM10 (and published in D3.1 and D3.3) illustrates that both enablers and barriers are very specific to the local landscape and policy context, however some general conclusions include: **Enablers:** existing supportive policies and legal frameworks, growing funding opportunities or financial support, municipal commitment, and growing scientific evidence in NbS	**Enablers:** interoperable monitoring technologies, trusted warning authorities, and co-designed communication practices. **Barriers:** limited technical capacity in some regions, data interoperability challenges, and declining public responsiveness to repeated alerts.	**Enablers:** availability of reliable risk data, increasing attention to climate-related financial risk, and collaboration between researchers and insurers. **Barriers:** regulatory complexity, limited familiarity with innovative financial instruments, and insufficient demand from end users.	**Enablers:** inclusive stakeholder forums, active local champions, and sustained facilitation processes. **Barriers:** stakeholder fatigue, uneven participation, and limited administrative capacity in local authorities.

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	performance and co-benefits. **Barriers:** institutional inertia and entrenched planning practices, limited NbS-specific expertise and knowledge (e.g. for design and long-term maintenance), fragmented governance arrangements, competing land-use priorities, and challenges related to long-term financing and ecological complexity under changing climatic conditions.			
Thematic Insights for Replication	• NbS replication is generally more likely to succeed when integrated early into **spatial planning and climate adaptation strategies**. • Framing NbS as **multi-benefit investments** (risk reduction, biodiversity, climate adaptation) significantly improves transferability. • **Cross-sectoral coordination and sustained collaboration** among all relevant actors are essential to support the NbS implementation process and facilitate their effective replication.	• Effective replication requires integrating **technological solutions with behavioural and governance considerations**. • EWS function best as **adaptive services** that evolve with user needs rather than as static technical systems.	• Scaling insurance solutions depends on **robust evidence of risk reduction and economic benefits**. • Blended finance approaches and **public–private cooperation** are key mechanisms for broader adoption.	• Governance innovations replicate primarily as **processes rather than fixed models**. • Long-term facilitation, peer learning, and institutional capacity building are essential for sustained impact.

C.2. Cross-DEM amplification patterns

Beyond the thematic clustering of demonstrators presented above, the interactions documented through the WP5 monitoring process reveal patterns in how innovations are amplified across contexts. These patterns correspond to the amplification domains defined in Deliverable D5.1,

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which distinguishes between amplifying within, amplifying out, and amplifying beyond. These domains describe whether innovations are stabilised within their original context, transferred across actors or locations, or embedded within broader governance, planning or financial systems.

C.2.1. Primary Amplification Processes

Across the HuT demonstrators, several distinct amplification dynamics can be observed.

First, a number of demonstrators focus on amplifying within, where innovations are stabilised and refined within the operational context in which they were initially developed. This process typically involves improving the usability, reliability or institutional embedding of technological tools or governance practices. Examples include the stabilisation of the VíZ24 technology supporting municipal flood management in DEM7 and the stabilisation of IoT monitoring technologies for hazard detection in DEM9. These cases illustrate how technological innovations can be strengthened through iterative use, stakeholder feedback and operational testing.

Second, amplifying out processes involve the transfer of knowledge, tools or practices between actors or locations. In the HuT project, this dynamic is particularly visible in DEM3, where monitoring expertise and early warning solutions developed in pilot municipalities are shared with other municipalities in the Campania region. This form of amplification relies strongly on knowledge exchange, peer learning and regional collaboration mechanisms.

Third, several demonstrators pursue amplifying beyond, where innovations extend beyond their initial technical context and influence governance structures, planning processes or financial mechanisms. For example, DEM1 and DEM4 integrate climate and rainfall information into planning and decision-making frameworks, while DEM8 explores the combination of wildfire risk modelling with insurance incentives for prevention. In these cases, amplification occurs not only through technological improvement but also through institutional learning and policy integration.

C.2.2. Secondary Amplification Processes

Analysis of the interaction narratives suggests that several demonstrators exhibit amplification dynamics beyond their primary classification in the Amplifying Stories. Technology-oriented demonstrators often combine stabilisation processes within the demonstrator context with emerging outward transfer of tools and practices. Governance-oriented demonstrators frequently combine institutional embedding with knowledge exchange across stakeholder networks, while community-oriented demonstrators link scaling-deep processes with broader dissemination of engagement formats. These patterns indicate that amplification trajectories in the HuT project are often hybrid rather than confined to a single amplification domain.

- **technology DEMs** often move from **within** to **out**
- **governance DEMs** combine **beyond + out**
- **community DEMs** combine **beyond + deep scaling**

Secondary Amplification Processes Observed from Interaction Descriptions

DEM	Primary Process (Amplifying Stories)	Additional Processes Observed from Interaction Narratives	Likely Sub-Processes
DEM1	Amplifying beyond	Some **Amplifying out** signals	scaling deep, awareness diffusion
DEM2	Amplifying beyond	**Amplifying within** clearly present	stabilising, operational refinement
DEM3	Amplifying out	**Amplifying beyond** visible	scaling deep (community awareness)
DEM4	Amplifying beyond	**Amplifying out** visible	knowledge transfer through stakeholder forums
DEM5	Amplifying beyond	**Amplifying out**	spreading narratives and awareness formats
DEM6	Amplifying beyond	**Amplifying within**	stabilising platform and operational tools
DEM7	Amplifying within	**Amplifying out**	transferring practices to municipalities
DEM8	Amplifying beyond	**Amplifying within**	stabilising modelling and incentive mechanisms
DEM9	Amplifying within	**Amplifying out**	spreading technology knowledge through partnerships
DEM10	Amplifying within	**Amplifying beyond** clearly visible	scaling up governance insights

C.3. Cross-DEM patterns in Enablers vs Barriers

Across the HuT demonstrators, the balance between enabling conditions and barriers varies considerably and reflects differences in institutional context, technical maturity, and stakeholder engagement. Demonstrators characterised by strong interaction intensity and well-established governance partnerships generally report higher volumes of enabling factors, suggesting that active collaboration and institutional embedding support amplification processes. Conversely, demonstrators operating in complex regulatory environments or with limited operational capacity tend to report more barriers, often related to coordination challenges, data integration, or resource constraints. The comparative analysis therefore indicates that replication potential is not determined solely by the technical quality of solutions but also by the broader enabling environment in which they are implemented. Demonstrators where enabling conditions outweigh barriers and where interaction intensity is high appear particularly well positioned to support replication through knowledge exchange, policy learning, and institutional cooperation.

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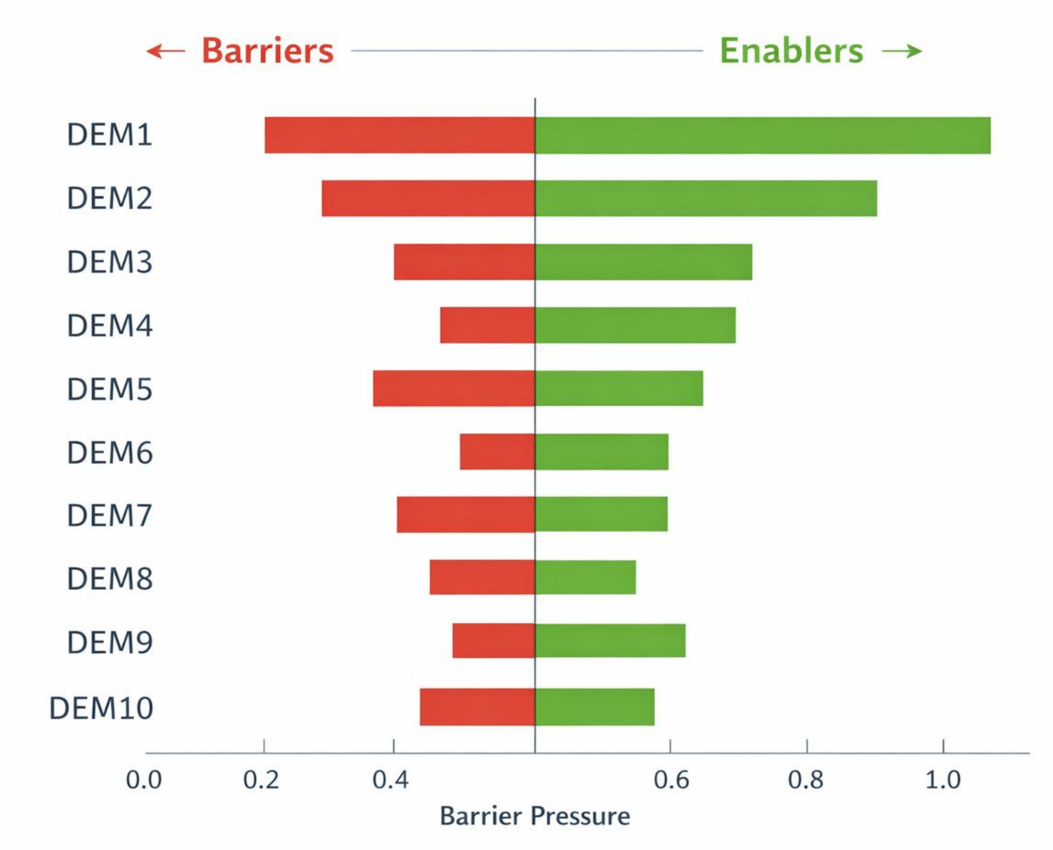

Enablers vs Barriers per DEM

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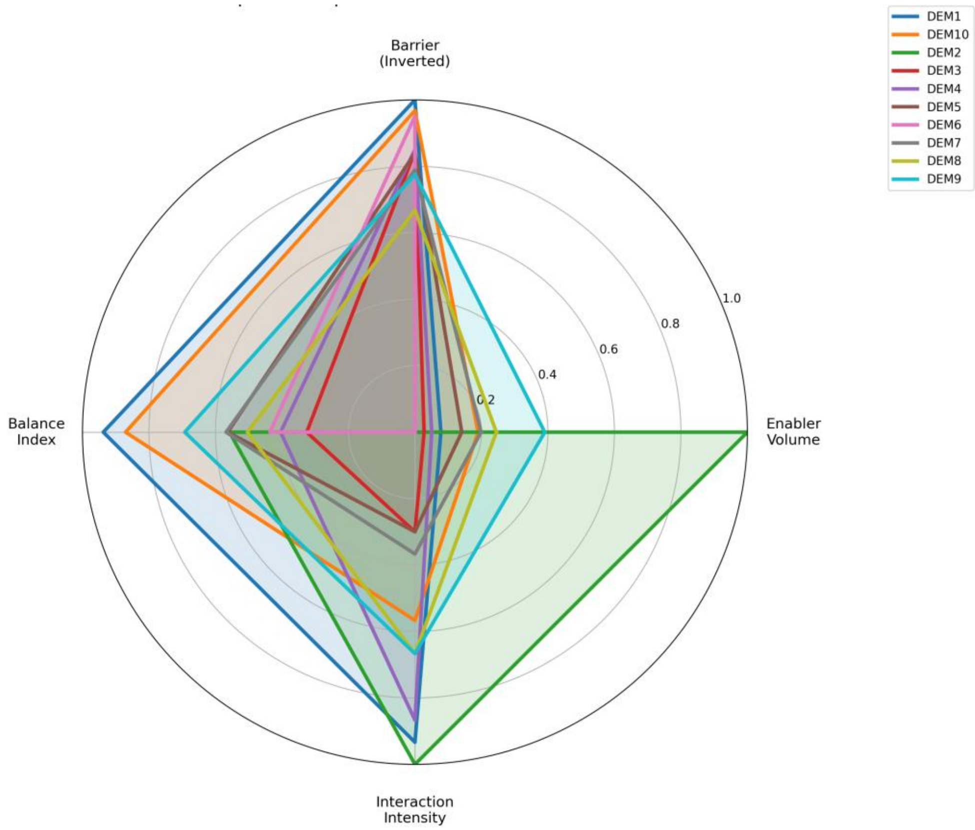

Comparative Replication Profile Radar Across DEMs

Enabler Volume

Higher values indicate a larger number of reported enabling conditions supporting amplification and replication processes.

Barrier (Inverted)

- Higher values indicate fewer reported barriers.
- Lower values suggest stronger constraints affecting the demonstrator.

Balance Index

Measures the relative balance between enablers and barriers.

- Higher values = enabler-dominant context
- Lower values = barrier-dominant context.

Interaction Intensity

Represents the volume of reported interactions with stakeholders, institutions, or networks.

- Higher values = stronger engagement and knowledge exchange
- Lower values = limited interaction activity.

Polygons – Demonstrators

Each polygon represents one DEM.

- Larger and more balanced shapes indicate stronger overall conditions for replication.
- Narrow or uneven shapes suggest that barriers, limited interactions, or weaker enabling conditions may constrain replication.

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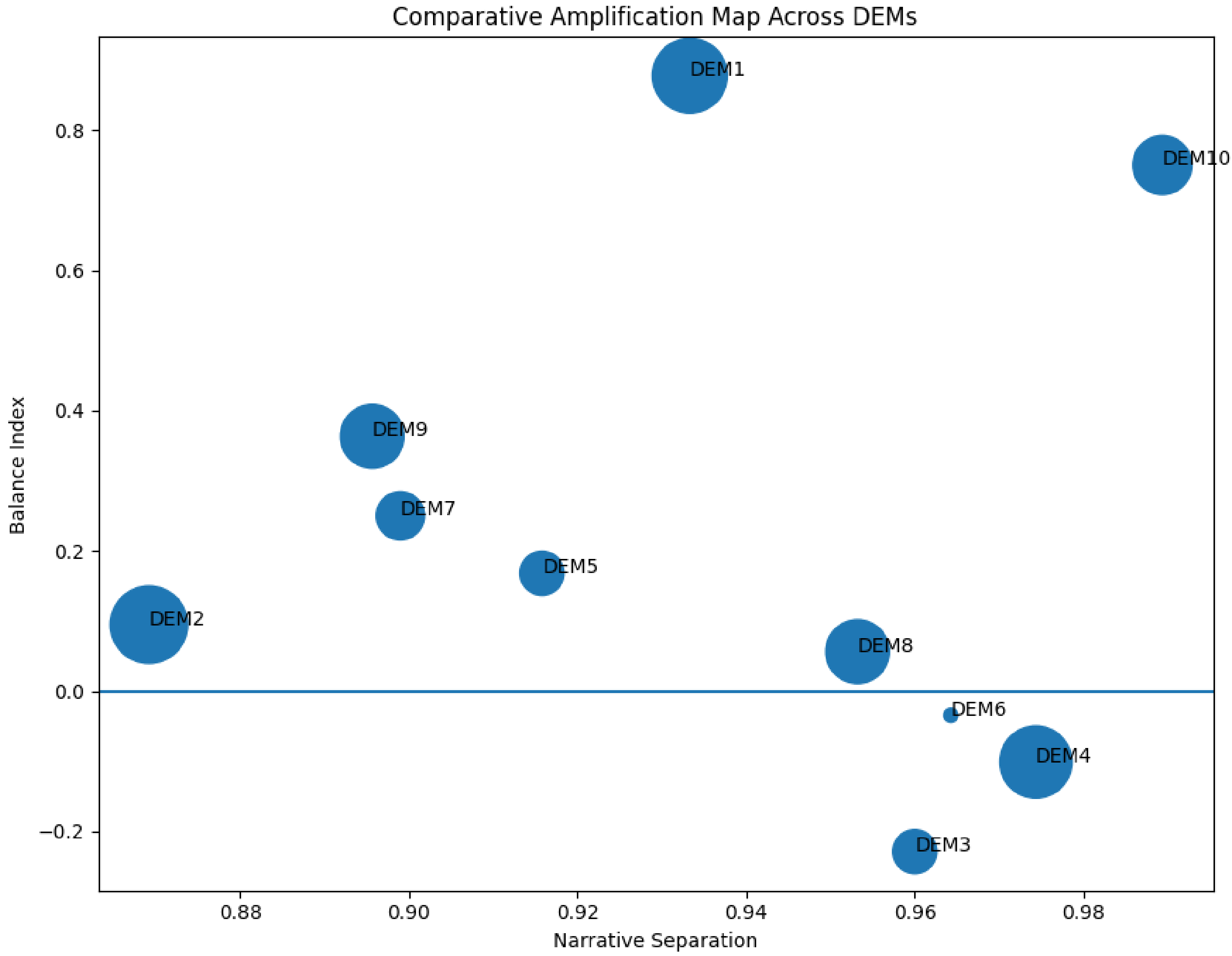
The comparative visualisation highlights notable differences in the amplification environments across the demonstrators. Several demonstrators display relatively balanced profiles characterised by high interaction intensity and a predominance of enabling conditions, suggesting favourable contexts for replication. Others exhibit more uneven profiles where barriers or limited interaction volumes constrain amplification processes. These differences illustrate how replication potential depends not only on the maturity of the innovation itself but also on the surrounding institutional, social, and governance conditions.



Comparative Amplification Map Across DEMs

X-axis - Narrative Separation

- Right = strong distinction between enablers and barriers
- Left = more conceptual overlap

Y-axis - Balance Index

- Above 0 = enabler-dominant
- Below 0 = barrier-dominant

Bubble size - Interaction Intensity

- Larger bubble = more interaction activity
- Smaller bubble = limited engagement volume

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C.4. Cross-DEM Narrative patterns

The analysis of interaction narratives across the HuT demonstrators reveals **three dominant amplification orientations corresponding to the Human–Technology Nexus:**

- technological system development (e.g., DEM2, DEM7, DEM9),
- governance and institutional embedding (e.g., DEM4, DEM8, DEM10),
- and community engagement and risk awareness (e.g., DEM1, DEM3, DEM5).

C.5. Implications for replication pathways

The amplification patterns identified above also provide important insights into the potential pathways for replication of HuT innovations in other contexts. Different amplification mechanisms correspond to different ways in which solutions may spread beyond the original demonstrator locations.

Technological stabilisation processes, such as those observed in DEM7 and DEM9, create opportunities for replication through technology transfer and adaptation. Once monitoring systems or digital tools have been stabilised in operational settings, they can potentially be adopted by other regions facing similar hazards.

Knowledge transfer processes, exemplified by DEM3, support replication through peer learning and collaboration between regions or institutions. In such cases, replication occurs through the exchange of experience and expertise rather than through the transfer of a single technological solution.

Other demonstrators illustrate replication pathways that rely on institutional or policy integration. For instance, the integration of climate information into planning processes (DEM1, DEM4) demonstrates how decision-support tools can influence governance practices and spatial planning frameworks.

Finally, some innovations involve financial or governance mechanisms that may enable broader systemic change. The exploration of insurance-based incentives for wildfire risk reduction in DEM8 and the governance frameworks for nature-based solutions in DEM10 illustrate how financial instruments and policy frameworks can facilitate the wider adoption of disaster risk reduction strategies.

While individual demonstrators combine several amplification mechanisms, four broad replication archetypes can be observed across the project. The replication archetypes presented below are derived from recurring amplification dynamics observed across the demonstrators and synthesised from the replication case files. They represent the dominant mechanisms through which HuT innovations may extend beyond their original contexts.

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Emerging Replication Archetypes

Emerging Replication Archetype	DEM examples
Technology stabilisation	DEM2, DEM7, DEM9
Knowledge transfer	DEM3, DEM6
Governance innovation	DEM1, DEM4, DEM10, DEM8
Incentives and behavioural change	DEM5, DEM8

Taken together, these observations suggest that replication within the HuT project is not limited to the direct transfer of technologies but may also occur through policy learning, institutional cooperation and financial innovation. These insights provide the foundation for the Replication Roadmap developed in Deliverable D5.5, which will further explore how the innovations demonstrated in HuT can be adapted and implemented in other regions and governance contexts.

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