Design and Development of a Gameful Co-Design Tool for Interventions in Rural Areas

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Abstract

Addressing sustainable development challenges in rural areas requires innovative solutions that effectively engage diverse stakeholders in collaborative co-design processes. This paper presents the development of a gamified phygital (physical and digital) co-design tool designed to foster active participation, enhance motivation, and enable the collaborative creation of Smart Innovation Packages (SIPs)—comprehensive solutions comprising technological and non-technological components aimed at addressing rural challenges. Unlike existing domain-specific tools, this approach uniquely combines gamified progress tracking, visual feedback, and recognition systems with a flexible, domain-agnostic framework, allowing its application across diverse co-design contexts. Furthermore, the tool integrates both digital efficiency and analog interpersonal strengths, a rarely combined approach in current tools, enabling broader accessibility for resource-constrained rural areas. A use case scenario in forestry management demonstrates the tool's application, highlighting its ability to guide stakeholders through problem identification, solution ideation, and intervention refinement. While the tool shows significant promise in enhancing stakeholder motivation and collaboration, its current limitation lies in the need for further empirical validation, particularly regarding its scalability and adaptability in long-term multi-contextual scenarios. This paper contributes to the growing field of gamification in co-design by offering a versatile and inclusive approach to tackling sustainability challenges in rural areas.

Keywords

Co-design, sustainable development, gamification, rural areas, phygital tool, stakeholder engagement

1. Introduction

Issues like poverty, inequality, climate change, and environmental degradation are commonplace in contemporary society. The Sustainable Development Goals (SDGs), established by the United Nations in 2015, represent a universal framework to address these global challenges [1]. Achieving these goals is not trivial, as it requires coordinated efforts across sectors, regions, and industries, along with innovative technological approaches to tackle the complexity of sustainable development and, at the same time, involve citizens in these initiatives [2].

It is crucial to involve stakeholders directly in the design of public interventions and their implementation process [3], which involves the practical execution of the intervention, such as testing solutions, applying strategies in real-world contexts, and continuously monitoring and refining the outcomes based on stakeholder feedback. Stakeholders may range from local communities and policymakers to industry experts and environmental organizations. Their heterogeneity brings diverse perspectives, expertise, and needs that must be considered to ensure solutions are effective, equitable, and socially accepted. Engaging stakeholders early and consistently throughout the design process can lead to more informed decisions, foster a sense of ownership, and improve the alignment of solutions, such as digital twin implementations, with real-world challenges and sustainable outcomes [4]. However, it is not easy

9th International GamiFIN 2025 (GamiFIN 2025), April 1-4, 2025, Ylläs, Finland
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to actively involve stakeholders in such procedures. Indeed, it is necessary to adopt procedures that can maintain participants' active motivation and engagement over time, while also being flexible [5].

Game strategies proved very useful in keeping stakeholders active during the co-production of initiatives and campaigns [6]. Game elements, as well as variably complex game mechanics, can motivate and engage stakeholders during co-design activities effectively. Motivation can be fostered not only by crafting complex, integrated game mechanics and dynamics but also by adding individual game elements. As a result, gamification—i.e., the use of game design elements in non-game contexts [7]—is becoming an increasingly popular methodology. Indeed, it promotes motivation, creativity, playfulness, engagement, and overall positive growth and happiness in users [8]. This offers a complementary approach for fields that typically struggle to capture users' full attention and motivation, such as training [9], education [10], and behavior change [11]. Gamification encourages collaborative problem-solving [12] and maintains focus on shared goals by providing clear feedback and a sense of accomplishment. Unlike traditional game strategies, which may require fully immersive or competitive setups, gamification is flexible and adaptable, making it ideal for co-design activities that need to balance collaboration, creativity, and practicality [13].

We therefore developed a phygital (physical plus digital [14]) tool, within the European project SmartERA[1], to provide a gamified co-design platform to solve problems that rural areas are facing. These areas are characterized by lower population density, limited infrastructure, reduced access to resources compared to urban environments, geographical isolation, limited digital connectivity, and restricted access to specialized services [15]. The tool will be used with heterogeneous networks of stakeholders—including citizens—in the problem definition and solution definition processes. The outcome is the definition of Smart Innovation Packages (SIP), which are collections of innovative components comprising technological and non-technological solutions, business and sustainability models, and policies, all interlinked and essential for ensuring the effectiveness of the package.

The research questions guiding the present work are the following: (**RQ1**) *How can co-design sessions for rural interventions be effectively gamified?* (**RQ2**) *What requirements should a co-design tool have to cater to all the different stakeholder needs and foster motivation?* To answer these questions, we follow the design science research methodology (DSRM) [16] and develop a tool that is both physical and digital. In this paper, we focus in particular on the design and development of the digital side used in the workflow of the phygital toolkit.

In Section 2, we present an overview of existing digital systems involving a semi-systematic process. In Section 3, we follow a DSRM approach [16] to highlight the elements that are not considered by existing artifacts, defining the need for a new procedure and the features that such a procedure should carry. In Section 4, we present the design flow, describing the tool in Section 4.2. We report a possible use-case scenario in Section 5. Section 6 concludes the paper, highlighting the pros and cons of the tool, and the future steps to improve it.

2. Background Literature

The importance of multi-stakeholder engagement during the co-design activities lies in the ability to enhance a social connection before initiatives actually begin. This allows for improved outcomes and enables perspective exchange, such as knowledge sharing, which is essential for targeted interventions in certain areas [17]. Although *co-design* is commonly used to refer to the intervention production process generically, here a slightly revised terminology is employed. In particular, we use *co-design* to refer to the conceptualization phase, and *co-production* to refer to the process as a whole. This was necessary to better distinguish all the phases (which our approach covers) and maintain a term to describe it generically. Thus, the different stakeholders can be engaged in three different phases of the co-production processes: (i) co-design, (ii) co-development, and (iii) co-delivery (Figure 1) [18]. *Co-design* refers to the phase where a first conceptualization of the intervention is made and the first actions are taken, such as exploring the problem and mapping the stakeholders. *Co-development* refers

[1] https://smartera-project.eu/

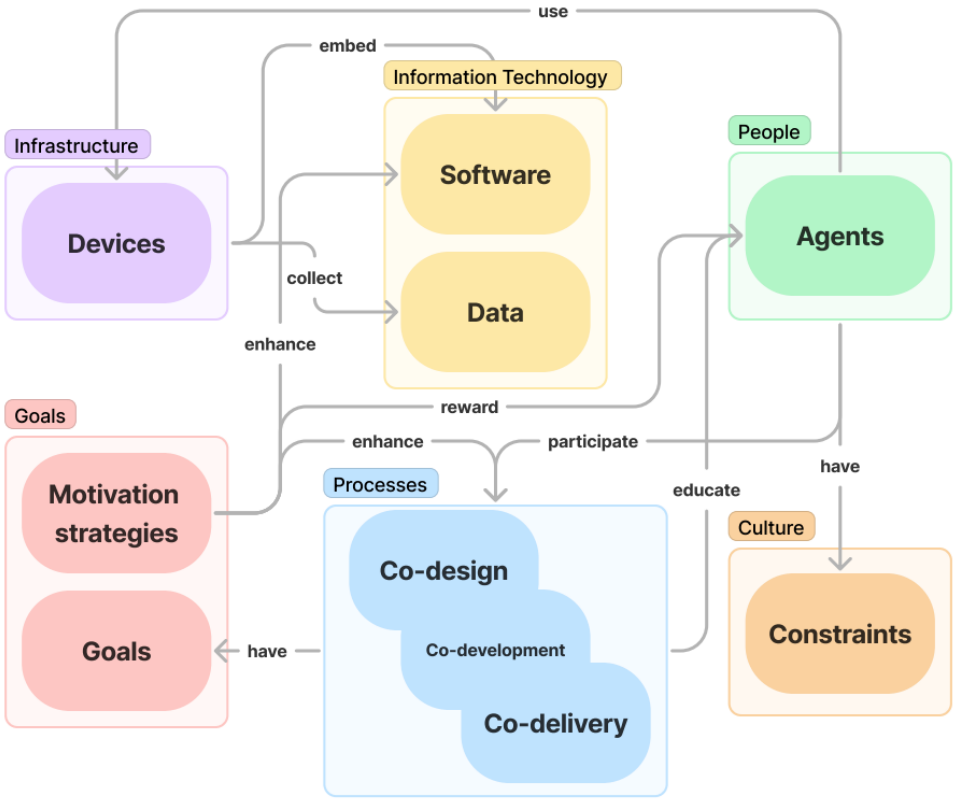

Figure 1: Conceptual model of a socio-technical ecosystem, revised from Bonetti et al., 2024 [18].

to the phase where the solutions to the problem identified in the co-design phase are developed and tested, such as new physical/digital tools, new services, or new processes and partnerships involving key agents. *Co-delivery* refers to the implementation and monitoring of the intervention in the target area involving the target population.

Gameful strategies have proven effective in maintaining stakeholder and civic engagement during co-production processes by fostering motivation, creativity, and collaboration [19, 20]. This stems mainly from their inherent ability to provide progress feedback, and creating a sense of achievement through structured interactions [21]. Therefore, we decided to analyze existing games and gameful systems empirically used during the co-production of interventions in rural areas. To analyze the gameful digital tools systematically, we conducted a search in two databases: Association for Information Systems (AIS) eLibrary (AISeL), and Scopus. These databases were chosen for the reason that they index all of the other potentially relevant databases, for example, ACM, IEEE, Springer, and the DBLP Computer Science Bibliography [21]. We used the query "*(TITLE-ABS-KEY (co-design) OR TITLE-ABS-KEY (codesign) OR TITLE-ABS-KEY (co-participation) OR TITLE-ABS-KEY (coparticipation) OR TITLE-ABS-KEY (participatory AND design) AND TITLE-ABS-KEY (gam*) AND TITLE-ABS-KEY (rural) OR TITLE-ABS-KEY (community) OR TITLE-ABS-KEY (collective AND actions))*", as the search term "gam*" takes into account all possible forms derived from the roots, i.e. game, gamification, and the verb gamify in all its forms. The search produced 173 results from the AISeL database and 355 from the Scopus database, totaling 528 hits. Then a snowball technique was employed, adding 15 potential hits by examining the references of the initial retrieved documents. This brought the total number of documents selected for the title and abstract screening to 543. We established the following inclusion criteria: (1) the study must report the use of digital game strategies during (2) co-design meetings that directly engage (3) stakeholders, aiming to foster (4) the co-production of interventions or collective actions for (5) communities or rural areas that (6) underwent an empirical use. We then excluded all studies that described tools or procedures without empirical application.

We ran a title-abstract screening through a double-blind peer review using the Covidence tool. Then,

we run a full-text analysis using a Google Sheet document[2], identifying 32 potential hits, that were further examined for relevance. The final pool was narrowed to eight (8) papers presenting five original digital tools and a commercial game (Minecraft), all of which demonstrated practical implementation and active stakeholder involvement in co-design contexts. This strict selection ensures the focus remains on tools with demonstrated impact, rather than conceptual models or purely theoretical frameworks (see Table 1). Figure 2 depicts an overview of the search methodology and screening process.

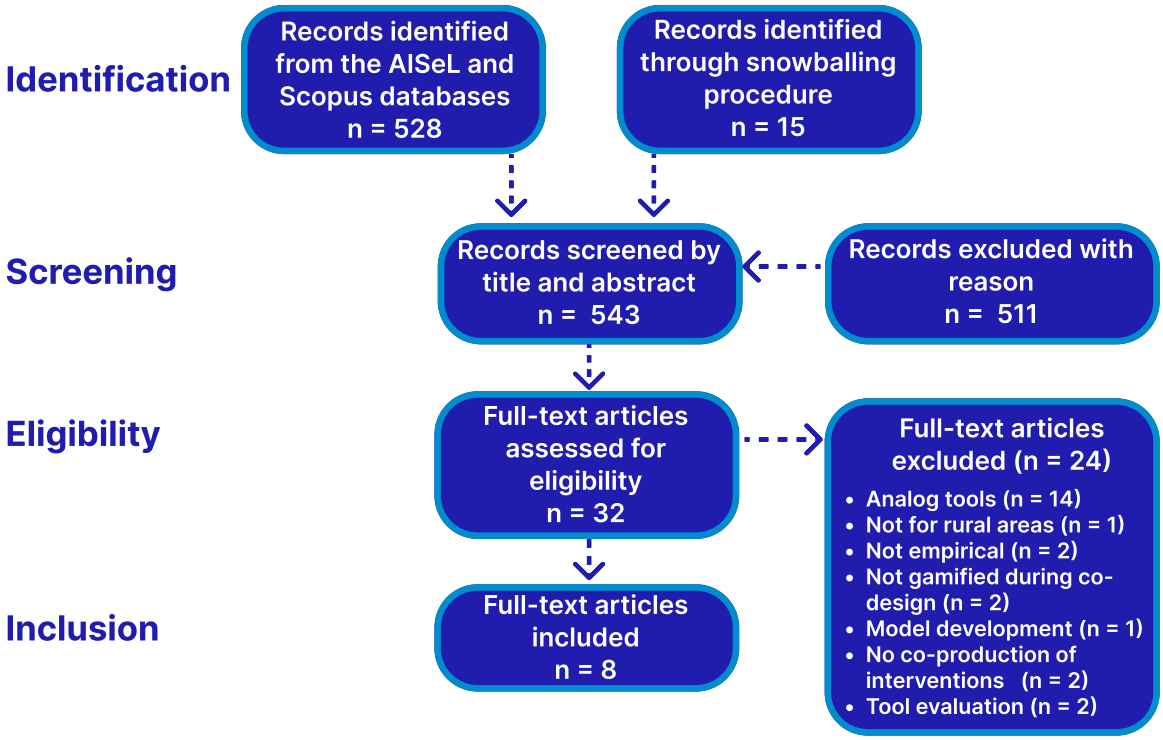

Figure 2: Study selection process.

Tool	Study domain	Phygital	Multi-stakeholder	Multi-domain
SimParc [22]	National parks management		•	
Maslow's Palace [23, 24]	Urban design		•	
Perugine [25]	Urban parks renewal		•	
Urban glitch [26]	Unused public spaces management			
AWARE RPG [27]	Water management strategies		•	
Minecraft [28, 29]	Public participation in urban design, Climate adaptation scenarios			•
SmartERA Tool	**Rural development**	•	•	•

Table 1
List of the gameful toolkits identified. The 'study domain' column refers to the practical use that was or is being reported for the tools.

SimParc [22] is a serious digital game aimed at participatory management of national parks for biodiversity conservation involving a role-playing game (RPG) approach. Each player has a specific role

[2]The Google Sheet can be retrieved here: https://osf.io/kd6y3/?view_only=c47fa3e3af5245c39ca1c97b7ccb2bc3

within the game and must try to resolve internal conflicts through dialogue, starting from a proposal, going through negotiation and review, and finally producing a shared decision on the issue addressed. The use of the game consists of an initial setup with role and scenario selection, then a "simulation and testing" phase with proposal, negotiation, revision, and manager decision sub-phases, and a final evaluation phase. During the empirical use, the authors engaged different stakeholders, including people from the local community, tourist and leisure sector, NGOs, administration, and decision-makers.

Maslow's Palace [23, 24] is a multiplayer, turn-based, digital participatory urban design game with the communities' collaborative input to generate social discourse and urban design ideation. The game specifically aims to help build social capital and slum-upgrading ideas among disparate stakeholders through gameplay and discussion. During the empirical use of the game, the authors implemented an initial setup with an ideation phase, then they proposed to explore conflict, values, and misunderstandings involving marginalized groups, such as migrants in [24], and the local community in [23] as stakeholders.

Perugine [25] is a digital card game specifically designed to improve decision-making on the renewal of urban parks. The deck represents the functions and services of the parks considered by the participants and evaluated within the context of the entire urban green system. Each deck of cards is created based on the players' ideas. It combines the visions of the local community for a specific green area with a complex overview evaluation of the entire urban green system. In the empirical use, it employed an initial setup with preparation and statement generation, then a strategic design phase including statement structuring, statement representation, interpretation of maps, and their utilization. During the process, the authors engaged the community, researchers and educators, administration, and decision-makers.

Urban Glitch [26] is a VR platform for participatory design aimed at providing a participant-informed perspective landscape, while targeting the issue of unused public spaces. The game consists of a chain of narrated scenes that guide the player through all the game stages. The main theme of the game is to create a design proposal using cubes within one or more architectural categories. The interaction among individual users is addressed by displaying other participants' most popular designs. During the empirical use in [26], the authors employed an initial setup aimed at gaining information by employing also public surveys. Then, data collection through public workshops with residents and local workers was carried out.

Aware RPG [27] is a simulation model based on the structure of the RPGs. It aims to investigate the economic efficiency, environmental sustainability, and social desirability of some water management strategies that catchment management agencies could potentially use. In this game, players impersonate different roles involved in water production, consumption, allocation, and demand. The authors held several workshops interspersing discussion and game sessions. The game sessions reported in [27] engaged students, researchers, and the water research commission in some phases: receiving results from the computer, negotiating, making choices, decisions on water purchase, and technology adoption. The discussion phase involved debriefing and group discussions. The outcome is a social learning environment, where different stakeholders can provide their views on the problem.

Two studies reported the use of a commercial game, **Minecraft**, during the co-design procedure for playful public participation in urban design [28], and to co-design climate adaptation scenarios [29]. Specifically, Minecraft is a sandbox video game that allows the creation of personalized scenarios, thus being able to imagine hypothetical futures, alternative realities, and redesign urban or natural contexts. In [29], the authors have created a virtual environment in Minecraft to engage 12- to 15-year-old children remotely. The authors aimed to engage children in co-designing climate adaptation scenarios for heritage-sensitive sites to make them more sensitive to the topic. In [28], the authors engaged the local community for public participation in urban design processes.

Overall, the review identified six tools that utilize gameful strategies to engage stakeholders in co-design processes, with five being original tools and one a commercial game (Minecraft). These tools span a variety of domains, such as biodiversity conservation, urban design, park renewal, and water management. Notably, all tools integrate game strategies rather than merely incorporating isolated game elements, emphasizing structured gameplay and narrative mechanics to foster collaboration, negotiation, and creative ideation among participants. However, a significant limitation emerges: all

identified tools are domain-specific, and designed for particular contexts or challenges. This specificity restricts their transferability and adaptability to broader or diverse co-design scenarios, particularly those targeting rural communities with unique needs and resource constraints. Moreover, while the tools demonstrate the potential of gameful approaches to enhance stakeholder engagement, their empirical applications reveal a lack of generalizability and scalability across socio–technical ecosystems. These findings underscore the need for more flexible, domain-agnostic tools capable of addressing varying stakeholder dynamics and project requirements. Such tools should combine the immersive and motivational aspects of game strategies with adaptability to different contexts, fostering broader application and impact in co-design processes. The following section presents a comparison between the issues identified from the analysis of existing tools and the requirements we set for our proposed tool, highlighting how the latter addresses the identified limitations, including domain flexibility, stakeholder inclusivity, and progress traceability.

3. Method and Analysis

The tool was developed using the Design Science Research Methodology (DSRM), with its steps illustrated in Figure 3. DSRM [16] provides a structured approach for systematically creating and refining innovative solutions to current challenges in Information Systems (IS). Through its iterative framework, DSRM guides developers in designing artifacts tailored to address specific issues.

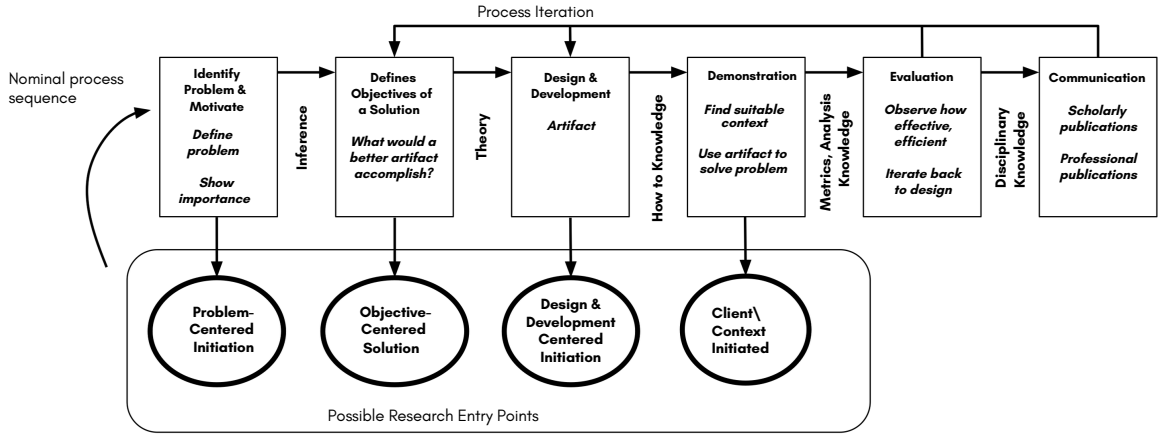

Figure 3: Design Science Research Methodology (DSRM), rearranged from Peffers et al., 2007 [16].

3.1. Problem identification and motivation

Following the first step of DSRM, we identified the issues analyzing the literature and the shortcomings of the existing tools. Our investigation revealed several critical shortcomings:

Limited use of gameful systems in co-design. While some gameful and playful approaches have been employed in co-design processes for collective actions, the integration of digital games or gameful systems remains sparse. Our review identified only five digital tools and a commercial game used for such purposes. This limited adoption indicates an underutilized potential for gamification in co-design.

Domain-specificity of existing tools. Most co-design tools are tailored to specific domains, such as park management, urban design, water resource management, or public spaces. This domain-centric design constrains their applicability, as these tools lack the flexibility necessary to address diverse contexts and challenges. A more versatile approach is necessary to meet the demands of multi-contextual co-design scenarios, particularly in dynamic environments like rural settings.

Absence of progress indicators. A significant gap among existing tools is the lack of indicators to monitor the health and progress of the co-production process. While many tools effectively facilitate

initial engagement or support specific intervention stages, they fail to provide mechanisms for ongoing tracking of contributions, stakeholder engagement, or the impact of collaborative efforts. This limitation hinders the evaluation of intervention effectiveness and long-term sustainability.

Inflexibility in stakeholder engagement and process adaptation. The digital tools identified in the review lack the adaptability required to accommodate the diverse time commitments of stakeholders. For example, key participants, such as administrative officials, may be unable to commit to lengthy co-design sessions due to competing responsibilities, leading to partial or disengaged participation. Additionally, most tools assume a linear co-design process starting with problem definition. However, in some cases, the challenges are already well-defined before co-design activities begin. This rigidity reduces the tools' effectiveness in accommodating varying stakeholder availability, ultimately limiting their usability and inclusiveness.

Weak integration of analog features. Many current co-design tools prioritize digital solutions for their organizational benefits, such as tracking decisions and documenting processes. However, they often neglect the social advantages offered by analog components, such as collaborative sketches, or in-person workshops. Analog methods naturally foster face-to-face interaction and trust-building, qualities essential for successful interventions in rural and community contexts. The lack of a strong phygital integration limits the ability of these tools to harness the complementary strengths of both methods, particularly in promoting social connections among stakeholders. Moreover, the lack of an analog counterpart often results in tools that are dependent on reliable internet access, which can be a significant barrier in rural or underserved areas where such resources are limited or inconsistent.

Limited Scalability and Customizability. Many existing co-design tools lack scalability, meaning they are not easily adjustable for projects of different sizes or complexity. Additionally, these tools often fail to provide sufficient customization options to align with the unique cultural, social, and environmental contexts of diverse rural communities. This limitation restricts their adoption across varied co-design interventions that may have differing goals and stakeholder requirements.

Insufficient support for stakeholder diversity. Current tools tend to assume homogeneity among stakeholders, overlooking the challenges posed by diverse groups with varying levels of expertise, technological literacy, and access to resources. This lack of inclusivity potentially skews the co-design process and outcomes.

Minimal emphasis on long-term engagement. The digital tools identified in the review focus on the immediate outcomes of the co-design process rather than fostering long-term engagement among stakeholders. This short-term perspective can lead to disengagement once the co-design sessions conclude, potentially undermining the continued impact of the interventions.

Poor visualization and comprehensibility. Overall, the digital tools identified with the review fail to provide intuitive, visually engaging interfaces or outputs that effectively communicate progress, decisions, and outcomes to the stakeholders. This lack of clarity can result in misunderstandings, reduced participation, and difficulty in aligning stakeholders with shared goals.

3.2. Definition of the solution's objectives

Following the second step of DSRM, we identified the features that such a tool should have to limit the problems we identified in the previous section.

Objective 1. *Flexibility.* An optimal digital tool should be flexible enough to support differences in the schedule, roles, and resource availability, allowing stakeholders meaningful participation. Moreover, it should support seamless transitions between different phases of the design process, from problem definition to solution definition and implementation. It must therefore be able to allow various stakeholders to participate for short periods but still have a voice in the process of co-design.

Objective 2. *Non-exclusivity.* To ensure the effectiveness of the tool in a broader range of situations, the tool should not rely on a specific domain or type of intervention. By avoiding exclusivity, the tool can be adapted to diverse contexts and project scopes, thus enhancing its utility across multiple sectors and making it accessible to a wider range of stakeholders. Moreover, the resources should be used within different methodological frameworks, such as the service design approach [30], and design

thinking [31].

Objective 3. *Non-exhaustiveness* Given the dynamic nature of co-design projects, an optimal tool should avoid rigid templates or exhaustive pre-defined workflows. Instead, it should allow users to customize the process, adding, modifying, or removing components as needed. This non-exhaustiveness enables the tool to respond fluidly to emerging needs and priorities during the design process; thus, new resources should be added progressively as the project advances and involved sites can contribute content during the process.

Objective 4. *Traceability of progress over time.* The tool must favor the traceability of progress by recording contributions, decisions, and adjustments over time. This feature allows stakeholders to monitor the evolution of the project, assess its trajectory, and understand the impact of individual contributions. Clear traceability supports accountability and provides a historical overview that aids in evaluating outcomes and refining processes.

Objective 5. *Visibility of results and comparison.* To foster an informed and reflective design process, the tool should make results visible to all participants and enable comparison between different intervention options or stages. By providing transparent and accessible visualizations, stakeholders can evaluate and contrast outcomes, facilitating informed decision-making and collective refinement of proposed solutions.

Objective 6. *Facilitation of documentation.* Efficient documentation is essential for capturing knowledge and insights generated throughout the project. The tool should simplify the documentation process, allowing stakeholders to record key decisions, feedback, and revisions in a structured and accessible manner. This facilitates continuity and knowledge transfer, particularly when new participants join or existing members are temporarily unavailable.

Objective 7. *Motivation for contributions and task completion.* The tool must actively motivate stakeholders to contribute and complete tasks by integrating elements that recognize individual input and collective progress. Mechanisms such as feedback loops, progress markers, or recognition systems can encourage sustained engagement and drive the completion of project milestones. By supporting both individual and group motivations, the tool fosters a collaborative atmosphere essential for successful co-design initiatives. An overview of the identified features is depicted in Figure 4.

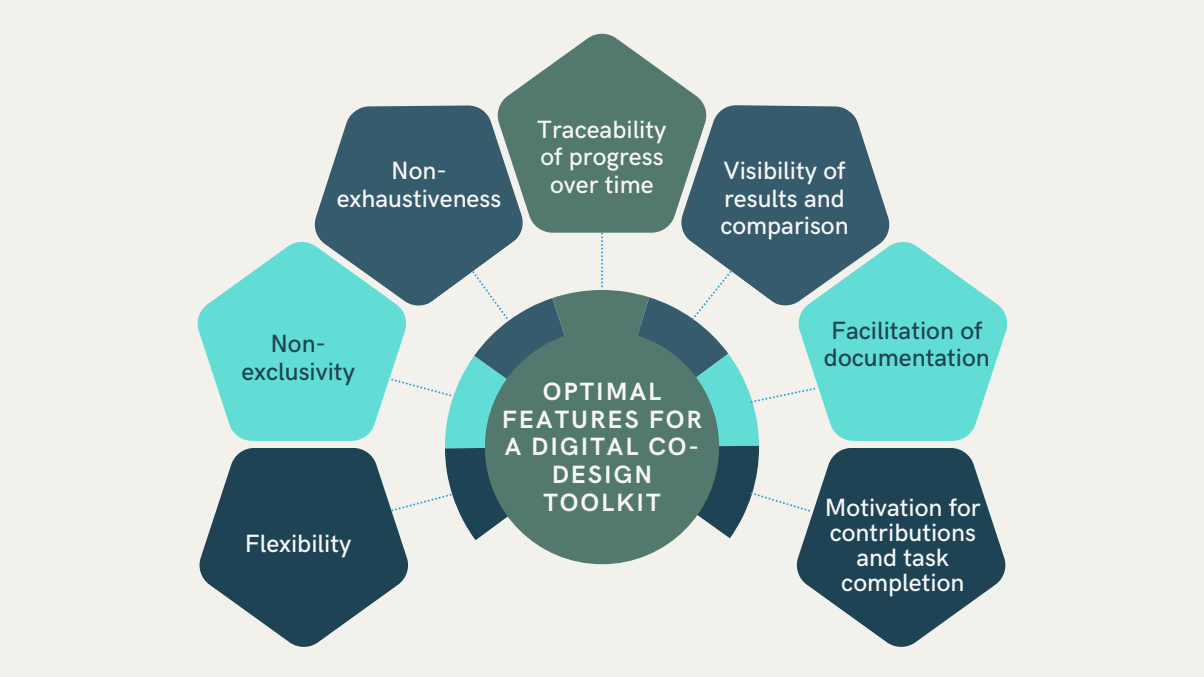

Figure 4: The features identified during the second step of the DSRM.

4. Design and Development

In this Section, we present the design and development of the tool, starting from a guideline to counter the limitations and implement the features presented in the previous section, and depicted in Figure 4.

4.1. Roadmap

Based on our objectives (Section 3.2) and the challenges identified in existing tools following the first step of DSRM (Section 3.1), we held numerous brainstorming meetings to identify the specific features of our tool. Then, we extended the results in a roadmap for the development.

Requirement 1: *Adaptive participation modes.* To accommodate different user preferences and contexts, the designed tool allows flexibility in its application as a fully physical, fully digital, or hybrid system (**Objective 1**: Flexibility). This adaptability ensures that stakeholders with varying levels of digital access or expertise can engage effectively. Whether in resource-constrained rural settings or digitally proficient urban environments, the tool's hybrid nature caters to a broad range of users (**Objective 2**: Non-exclusivity).

Requirement 2: *Data transfer.* Recognizing the need for continuity between physical and digital activities, the tool includes streamlined mechanisms for transferring data from physical to digital formats. This capability preserves the value of in-person interactions while enabling digital documentation and analysis, ensuring that no information is lost between mediums (**Objective 1**: Flexibility; **Objective 6**: Facilitation of documentation).

Requirement 3: *Structured collaboration management.* To support large-scale and collaborative co-design projects, the tool implements a user privilege system. This feature allows administrators to assign specific access levels, enabling designated "pilot orchestrators" to access data, compare project outcomes, and disseminate results across multiple projects. By facilitating information sharing, the privilege system supports cross-project learning and transparency (**Objective 4**: Traceability of progress).

Requirement 4: *Simultaneous multi-project capability.* The tool's architecture is designed to accommodate multiple projects, or "pilots", concurrently. This multi-project functionality allows stakeholders to manage and compare different interventions within the same interface (**Objective 5**: Visibility of results and comparison), promoting efficiency and enabling a comprehensive view of various initiatives (**Objective 4**: Traceability of progress). Additionally, this capability supports iterative learning, as insights from one pilot can inform adjustments in others.

Requirement 5: *Universal applicability.* To extend the tool's applicability across different types of co-design initiatives, we have adopted a domain-agnostic approach. This feature makes the tool easily adaptable to various contexts, from rural planning to urban design or environmental sustainability interventions (**Objective 2**: Non-exclusivity). The tool's modular design allows for rapid customization, making it suitable for a wide range of co-design applications without requiring significant reconfiguration (**Objective 3**: Non-exhaustiveness).

Requirement 6: *Engagement through visual feedback.* Incorporating gamified elements, the tool visualizes progress through icons that provide a clear, accessible indication of advancement. Unlike raw quantitative metrics that vary widely across projects (such as participant numbers), these icons offer a standardized representation of project milestones, enhancing user motivation and engagement (**Objective 4**: Traceability of progress). This gamified approach encourages stakeholders by clearly showcasing the project's journey and achievements (**Objective 7**: Motivation for contributions and task completion).

Requirement 7: *Guided process framework.* The tool incorporates the Double Diamond model [32], a widely accepted design methodology that organizes the co-design process into four stages: Discover and Define within the "problem definition" phase, and Develop and Deliver within the "solution definition" phase. This procedural framework guides users through structured phases, ensuring a comprehensive approach to problem-solving and innovation. The Double Diamond implementation supports a balanced exploration of problems and solutions, fostering systematic progress in co-design initiatives (**Objective**

3: Non-exhaustiveness; **Objective 4**: Traceability of progress).

4.2. Toolkit

In this section, we present the final toolkit in its analog and digital components. The aim of the toolkit is to assist the collaborative processes and the transparent communication within the network of stakeholders participating in the discussion of solutions to rural development challenges. The toolkit is expected to facilitate the identification of so-called "ingredients" (components) of a Smart Innovation Package. Different categories of ingredients that are crucial for implementing rural innovation solutions have been identified, such as: data and knowledge on context, software, best practices, communication and training, incentives, financial and economic enablers, infrastructure, equipment, political/legal aspects, and people. The term 'ingredient' was chosen as it is more specific than 'element' or 'component', it is used in everyday speech and it intuitively activates the metaphor of a recipe, where properly combining essential ingredients results in an outcome that is more than the sum of its parts.

4.2.1. Analog tool

The first version of the toolkit consists of an analog set of components, including:

Board. It consists of a visual depiction of the assembled set of components, enabling progressive and iterative monitoring of the process outcomes while simplifying documentation.

Ingredient cards. They provide examples of components that can drive innovation in rural areas. These cards describe concrete examples of ingredients that can be used in the SIP and for which purpose (e.g., "drones", "local hero", a specific administrative figure, etc).

Reflection cards. They include checklists or reflection prompts to thoroughly evaluate each category of components. These cards contain general questions that help the stakeholders involved and the facilitator understand why some categories of ingredients can be important for the final aim.

Support canvases. Their aim is to support specific activities and encourage reflection on the process and interdependencies among components. Canvases are visual templates used to describe and analyze specific aspects of the SIPs. Completing the canvases can assist the group of stakeholders in identifying the necessary ingredients for the project. They can also propose collaborative activities, such as stakeholder mapping or workshops focused on exploring digital opportunities.

SIP description. This is the final outcome of the toolkit's use, providing a comprehensive documentation of the SIP developed during the co-production process. It summarizes key aspects from problem definition to solution, including: a general description, the challenges addressed, and the aspects of the rural territory and community targeted for innovation (e.g., mobility, governance, environment, services). The documentation should describe the location where the SIP was created and tested (e.g., rural, suburban, coastal) and outline the experimentation process. It should also list the stakeholders involved, describe their roles and contributions, and provide a visual summary of the SIP. Additionally, it should detail the SIP's components, lessons learned, economic sustainability, and observed outcomes after its implementation.

The analog toolkit can be used flexibly in different phases, for instance during the preparation of collaborative activities to support facilitators to become aware of different ingredients that should be considered and discussed with stakeholders, to enhance the collaborative activity during co-design, and after the collaborative activity to take notes on the ingredients and to make some final considerations. An overview of the analog elements is depicted in Figure 5.

The identification of the ingredients was informed by three collaborative workshops, each involving a group of 50 public and private actors who have engaged in social and technological innovation processes within six European rural areas involved in the SmartERA project: Val di Sole in Italy, Sóller in Spain, North Ostrobothnia in Finland, Trebinjie in Bosnia & Herzegovina, Šmarje-Padna in Slovenia, and Devetaki Plateau in Bulgaria. The process started with the collection of stakeholders' past stories of innovation, in which a solution for a specific issue had been designed and developed. We analyzed the various phases of their innovation journey and the barriers encountered as well as the main categories

Figure 5: Analog elements of the toolkit. From left to right, ingredient cards, board, support canvases (in the upper part), and reflection cards (at the bottom).

of ingredients that contributed to the development of innovative solutions. A literature analysis further allowed to deepen the understanding of the identified categories of ingredients and integrate what had emerged from rural stakeholders with existing research findings. During these workshops, preliminary feedback on the structure and contents of the analog version of the toolkit was gathered. The workshop aimed to assess the interaction with the toolkit's physical cards, canvases, and board during a creative session to conceive a potential solution for an on-demand public transportation service for a fictitious remote area. The complementary expertise of the different participants enabled them to collaboratively generate 73 different ideas for necessary ingredients, which were attached to the Board. By looking at the populated Board, workshop participants were positively surprised by such a rich collective output (visibility of results). However, they were unsure of what would be the following step. It clearly emerged that the analog materials effectively support the idea generation phase (divergent exploration), but require complementary functionalities that support reflection, ideas reordering and selection (convergent phase), traceability, and documentation of what is achieved at each step. The results of the evaluation thus provided evidence to the potential benefit of the digital version of the tool.

4.2.2. Digital Tool

The digital counterpart was developed using Unity (version 2021.3.25f1) to both support the physical version by enabling continuous and asynchronous monitoring of the SIP creation process and to enhance stakeholder engagement by offering real-time process indicators and achievement badges. The choice of Unity, which is a popular and widely used video game development tool, was dictated by its completeness and versatility: it offers the opportunity to extend the digital tool by allowing the creation of specific views and data visualization environments for the general public, enhancing the motivation part, and the easy addition of gameful elements. While creating a scenario, **facilitator**—the person who runs the co-design meetings—selects the phase, including stakeholder mapping, problem definition, solution identification, and delivery [33]. Therefore, the tool allows information to be collected during multiple phases. Initially, the digital tool presents a main board containing the possible ingredients, i.e., all the macro-categories of elements. This view is represented in the Figure 6. Each hexagon represents an **ingredient** category. Any numbers given inside the hexagons represent the number of **instances**

involved, that is concrete, individual occurrences that embody the characteristics of the overarching group or concept. Figure 6 shows for example a total of eight instances inserted within the ingredient "People".

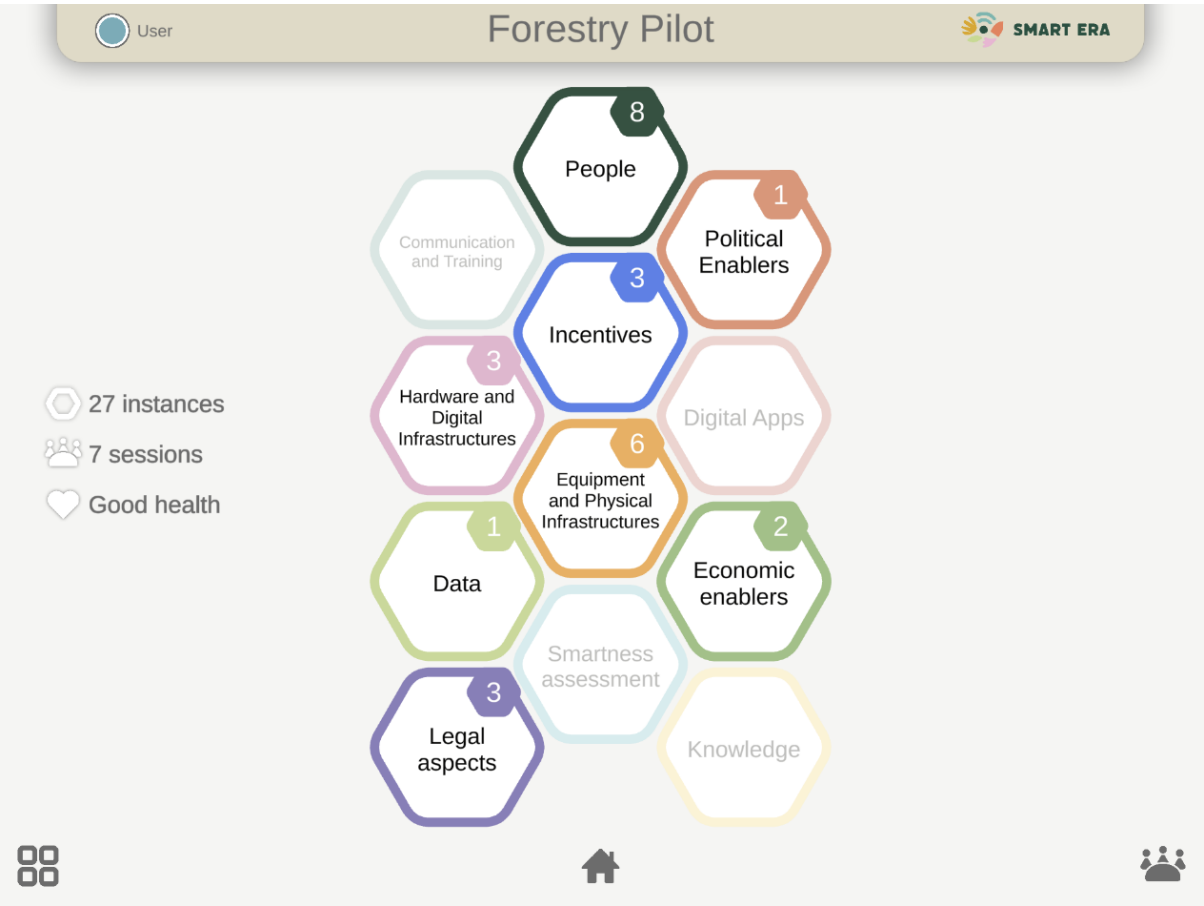

Figure 6: Project main view.

During the co-design, the facilitator selects the ingredient categories to be analyzed during a specific session. Currently, the list of ingredient categories includes "People", "Data", "Community knowledge", "Digital apps", "Communication and training", "Incentives", "Hardware and digital infrastructure", "Physical infrastructure", "Equipment", "Political enablers", "Economic enablers", "Legal aspects", "Smartness assessment of the territory". Numerous instances, i.e., elements or actors to be considered within the ingredient category, can be evaluated for each ingredient. Within the hexagons, it is possible to explore the various instances analyzed during the co-design process (Figure 7). In the example depicted in Figure 7, it can be seen that several instances, such as "Forestry specialist", "Local hero", and "Municipal advisor", have been reported as necessary to be involved during task definition.

To promote brainstorming and interaction between the stakeholders during the co-design phase, ingredient cards were digitalized starting from their analog version, representing different examples of instances. In Figure 7, the deck of cards for the chosen ingredient category, in this case "People", is available in the upper right corner. The cards consist of a *title*, a *description*, and some *usage examples* (Figure 8). The role of cards is only to make stakeholders think about the possible involvement of elements or actors in the process. For example, in the case of co-design of a forest conservation intervention, by finding the "Drone" card within the deck related to "Equipment", stakeholders can identify how that element might serve their purpose and what people are needed to operate. However, since the pool of ingredients and instances to be considered is almost infinite, it is possible to create additional cards or add instances that are not considered through a creation procedure (represented by the + symbol in the right corner of Figure 9).

Figure 7: People considered by stakeholders during the brainstorming session for co-design the solution definition.

Reflection cards have been implemented starting from the analog component. Similar to the analog version, they include checklists or reflection questions to explore the various "ingredients" of the process (e.g., people, data, equipment, etc.).

The digital tool incorporates a timeline view designed to provide a chronological perspective of the co-design process. This view visually maps the sequence in which various ingredients (i.e., the key components or elements of the intervention) and specific instances were addressed during each stage of the co-design workflow. By organizing the process temporally, the timeline view enables stakeholders to trace the evolution of decisions, activities, and outcomes across the intervention life–cycle. Points in time where the different ingredients were interacted with are represented by yellow dots. This feature facilitates reflection on the progression and interdependency of actions, offering insights into both the pacing and prioritization of co-design efforts. Additionally, the timeline enhances transparency and accountability by documenting when and how particular steps were completed, making it an essential component for both process evaluation and iterative improvements (Figure 10).

The digital tool also offers a view that allows a comparison between different areas or pilots involved in the process. Figure 11 depicts this section of the tool. This part allows facilitators, as well as involved stakeholders, not only to assess the progress of their own process but also that of other affected areas.

4.2.3. Gamification functionalities

Gamification was incorporated into the tool to enhance stakeholder engagement and motivation. Four main indicators convey the status of the project. In the pilot card (Figure 11), three icons appear: **number of instances**, **number of work sessions**, and **health of the pilot/SIP**. In addition, a **timer** at the top-right corner indicates how many days before the facilitator interacted with the tool. These

Figure 8: Digital representation of ingredient cards.

elements provide in detail the status of the co-design process. Specifically, the number of instances indicates to users how many ingredients' instances were evaluated in total within the project, providing an idea of how many actors and elements were identified for the creation of an SIP. The number of work sessions reflects how often stakeholders were involved, providing a sort of thermometer of the level of engagement of the stakeholder network. The health of the pilot/SIP is a measure that provides insight into how well the process is going, mixing data derived from the number and variety of stakeholders, number of working sessions, number of ingredients analyzed and instances created, and how often the facilitator interacts with the digital tool. The timer shows two pieces of information: it indicates how long it has been (in days) since the facilitator last updated and interacted with the digital tool and how much time remains before losing the next streak badge (in the form of an arc timer).

Achievements in the form of badges (Figure 12) were included for reaching certain milestones, such as engaging a certain variety of stakeholders or maintaining a streak of activities for a certain period of time. These activities consist of: the creation of work sessions; the interaction with previously created (and active) work sessions; the creation of new ingredient instances; and access on a weekly basis.

Through a user privilege system, only facilitators can enter items and edit the digital tool. Stakeholders can only navigate within the tool, in all its views, that is, interact with the board, investigate individual ingredients and instances, use the timeline view, compare the indices of the various areas involved, and see the current state of progress.

The use of the toolkit refers to the first step of an incremental process, composed of an initial co-design (toolkit use), implementation, delivery and evaluation, and sustainability and applicability. This roadmap enables the toolkit to be reused for addressing new issues identified during the evaluation phase. If successful, the resulting SIP can also be applied to solve similar problems in rural areas with comparable structures.

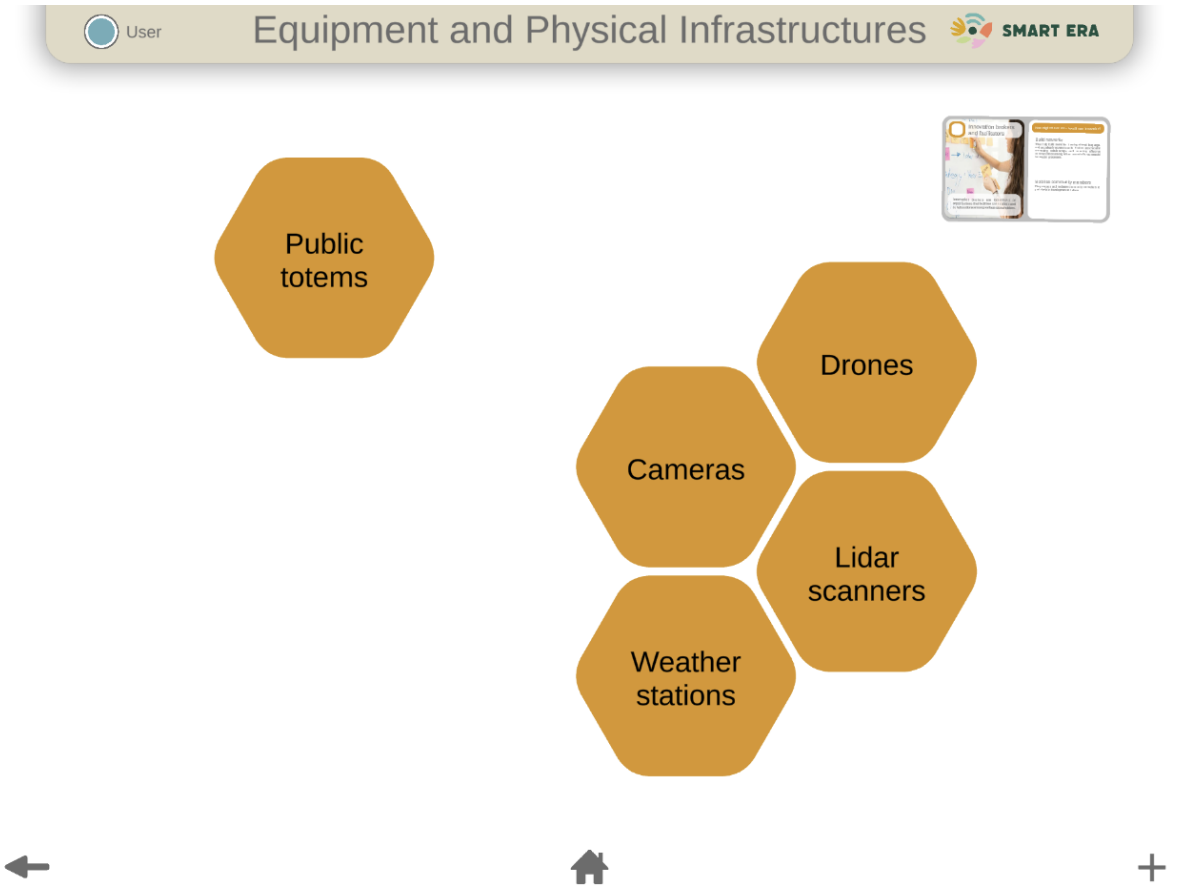

Figure 9: Equipment considered by stakeholders during the brainstorming session for co-design the solution definition.

5. Possible use-case scenario

In this section, we present a possible use-case scenario involving the digital tool's use in a case of forestry management. This hypothetical example aims to illustrate the tool's potential application rather than to demonstrate its proven effectiveness or efficiency. Further empirical testing in real-world settings is required to validate its impact.

In the initial phase, namely *problem definition*, the facilitator and a core group of stakeholders meet to identify any issues related to forest cover management while mapping the possible stakeholders to be involved during the following solution definition, and the possible ingredients. This phase is necessary to adequately prepare for subsequent workshops, familiarize with the ingredient cards, and select necessary materials, ingredients, and reflection cards to guide the brainstorming flow for each ingredient category. In the final part of this phase, the facilitator populates the digital board, deciding what ingredients should be discussed during the next meetings. For example, problems that can be identified here may be low wood availability, lack of biodiversity in the forest cover, and initial desertification of forest areas due to multiple factors, including urbanization, bark beetles, and climate change.

During the *solution definition* phase, the facilitator, core group, and stakeholders are involved in the process. The challenges have already been defined during the previous phase. Here, the stakeholders engage in brainstorming sessions using ingredient cards to define possible solutions to the challenges identified. At the same time, the facilitator populates the analog and/or digital board with the ingredients and instances identified during the discussion (Figure 6).

Specifically, equipment needed to address existing issues can be identified during the solution definition. In this case, stakeholders can suggest the use of drones, cameras, and Lidar scanners to

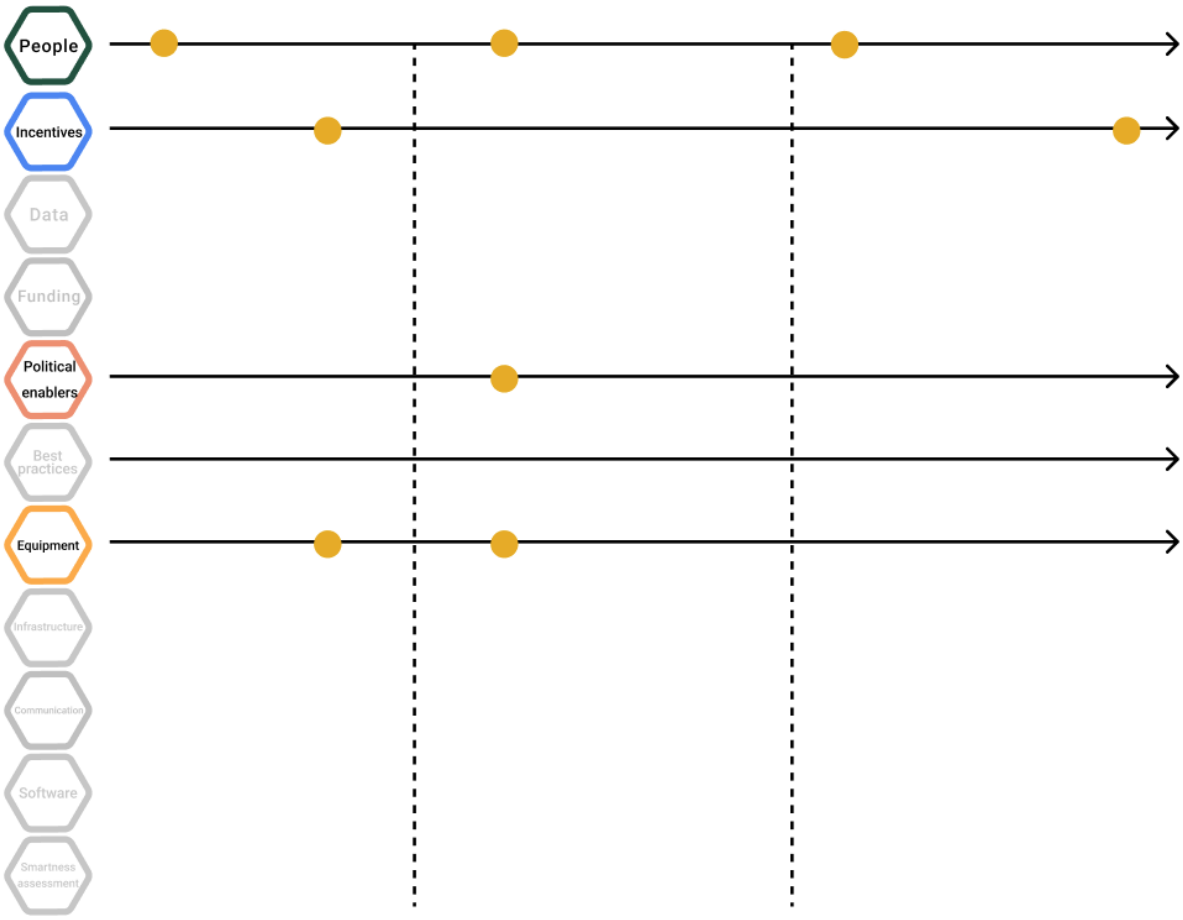

Figure 10: Timeline view. In this view, actions made during the sessions are laid out horizontally in chronological order. Yellow dots represent interactions with the intervention ingredients in time.

Figure 11: Pilot comparison view.

monitor the health of the forest and minimize adverse events. Moreover, specific weather stations placed in the forest can help reduce the impact of specific weather events. Public totems in the urban context can help local citizens in visualizing the current state of the forest and the importance of this intervention. Figure 9 provides the equipment considered for the solution definition.

Stakeholders can reason about what other categories of ingredients should be considered in the

Figure 12: Three different streak badges. From the left: weekly badge, biweekly badge, and monthly badge.

solution definition, and through the use of support canvases and ingredient cards, they can analyze which categories are related to the equipment just considered. For instance, specialists can be identified who deal with both the use of software and hardware of the proposed equipment, but also those who are responsible for analyzing the data, administrative staff needed to obtain permits, operators needed for forest reforestation, plant cultivation, but also local citizens needed to process the wood that is removed from the forests. Figure 7 provides the people considered for the solution definition. After using the tool as an aid during several co-design workshops, the elements considered within the tool are reported in the SIP description template, creating a package that provides elements and actors necessary for solving a set of given problems.

To test the actual effectiveness of our tool, we will apply our the co-design toolkit to six different scenarios: (1) in Italy, the tookit will be used to promote the protection of natural and cultural assets, and to promote the agricultural development; (2) in Spain, it will be adopted for the digitalization of economy and data-sharing, in particular in the context of tourism and agriculture; (3) in Finland, it will be used to promote platform economy; (4) in Bosnia and Herzegovina, the toolkit will be adopted to foster rural tourism, enhancing related digital services (e.g., marketing and sales); (5) in Slovenia it will be used to promote sustainable mobility, sustainable tourism, and to engage the community in circular economy; and (6) in Bulgaria the toolkit will be applied to the enhancement of connectivity infrastructures, and the development of healthcare centers for remote consultation.

6. Conclusion

In this paper, we presented the design and development of a gamified co-design tool that integrates physical and digital elements to address sustainability challenges in rural areas. Rooted in the principles of the Design Science Research Methodology (DSRM), the tool was developed to address key limitations of existing co-design tools, such as limited flexibility, domain-specificity, and lack of progress tracking. By leveraging gamification , the tool promotes active and meaningful engagement while fostering collaboration and creativity. The analog and digital components of the tool were designed to complement each other, empowering stakeholders regardless of technological proficiency or resource constraints. The digital counterpart incorporates features such as gamified progress tracking and multi-project capabilities. The analog side aims to strengthen interpersonal interactions and social bonds, enhancing trust among participants.

A use case scenario in forestry management demonstrated the tool's potential to facilitate the co-design of Smart Innovation Packages (SIPs), which combine technological and non-technological solutions tailored to local needs. While the phygital tool has the potential to offer significant advantages, some limitations remain. These include the need for further testing in diverse contexts to validate its scalability and accessibility. Future work will focus on these aspects, as well as on integrating additional gamified elements. Another limitation is that, at the moment, the digital tool requires a computer to be run (e.g., to show the digital board in a workshop session to the participants). However, in the future, it should be adapted for mobile devices to allow swifter interaction and data upload. To assess the effectiveness and flexibility of our toolkit, it will be used in the European project SmartERA in six

different countries, to identify and tackle challenges related to sustainable development in rural areas.

In conclusion, the proposed tool represents a step forward in leveraging gamification and phygital design to address sustainability challenges through inclusive and collaborative co-design processes. Its ability to engage stakeholders and create actionable solutions underscores its potential as a valuable resource for rural and community development initiatives. Furthermore, the tool aligns with broader trends in digital transformation by emphasizing hybrid participation models that merge digital and physical elements, enhancing both accessibility and stakeholder engagement. This approach reflects current trends in digital transformation research, where technology is increasingly employed not only to support collaboration but also to ensure traceability, data-driven decision-making, and continuous innovation throughout participatory processes [34]. These characteristics position the tool as part of a larger movement toward the use of digital ecosystems for sustainable development, aligning with calls for more adaptable and transparent co-design solutions.

Acknowledgment

This work is co-funded by the European Union's Horizon Europe Framework Programme SmartERA (https://smartera-project.eu/), under the Grant Agreement no: 101084160. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or REA. Neither the European Union nor the granting authority can be held responsible for them.

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