

Participatory Scenario Analysis and Rural Sustainable Innovation: A Mixed-Methods Study of Multi-Stakeholder Policy Co-Creation

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Abstract—Rural sustainable innovation is shaped simultaneously by climate risk, digital divides, organizational fragmentation, and conflicts among values. Conventional linear consultation and static strengths–weaknesses analysis provide limited insight into how diverse actors jointly define problems, compare alternative futures, and convert agreement into executable policy. This study advances a scenario–prototype–portfolio–feedback framework for policy co-creation and examines its evidentiary basis through a sequential mixed-methods synthesis. The corpus comprises 36 sources published from 2021 to 2026 and verified through publishers, digital object identifiers, or official government websites; 33 are peer-reviewed articles. First, a quantitative evidence map structurally coded topics, methods, regions, five mechanisms, and five outcomes. Second, a qualitative thematic synthesis identified relationships among inclusion, knowledge integration, policy prototyping, portfolio selection, and institutional embedding. Third, policy-tool priorities were calculated using four criteria—evidence coverage, geographic breadth, implementation depth, and risk control—and tested under four weighting schemes. Institutional embedding and executability co-occurred in 26 sources, policy prototyping and executability in 23, and both knowledge integration and portfolio selection with resilience in 19. Participatory monitoring and feedback ranked first under all four weighting schemes, with scores from 84.0 to 87.9. Farmer data rights and governance, followed by inclusive access and capacity building, ranked second and third under balanced weights. The central value of participation lies not in increasing meeting attendance, but in establishing traceable knowledge translation, allocation of responsibility, rights protection, and iterative learning. The study reframes participatory scenario analysis from a visioning technique into a design infrastructure and offers a reusable co-creation protocol for policy portfolios concerning digital rural development, climate adaptation, and agricultural socialized services in Chinese counties.

Keywords—participatory scenario analysis, rural sustainable innovation, policy co-creation, mixed methods, multi-criteria decision analysis

I. INTRODUCTION

Rural sustainable innovation is not simply a question of adopting a single technology. It involves interdependencies among climate shocks, land and ecological constraints, economic returns, public services, organizational capacity, and data rights. Digital agriculture can broaden access to knowledge and services, but it can also reproduce existing

inequalities. Global evidence shows that smallholders have substantially weaker data connectivity and digital-service coverage than large farms, while resource endowments, gender, literacy, and social capital shape how services are used [1][2][3]. Research in China likewise identifies a positive association between digital rural development and rural revitalization, although the association varies by location, infrastructure, and industrial function [4]. A configurational analysis of 84 digital-village pilots further indicates that no single technological condition is sufficient; governance effectiveness depends on combinations of social and technical conditions [5]. Policy design must therefore ask not whether to digitalize, but under which futures, by whom, and through which institutional and service portfolios digitalization should proceed.

Participatory scenario planning offers a framework for comparing multiple futures. Rather than predicting one future, it organizes stakeholders to identify drivers, critical uncertainties, and value trade-offs, then tests alternative policy portfolios across plausible scenarios [6][7][8]. Recent cases have linked local visions with remote sensing, land-cover analysis, ecosystem services, and systems-feedback models to create a sequence of narrative development, indicator-based or spatial projection, and feedback-driven revision [9][10][11]. Scenario workshops can nevertheless remain at the level of shared visions. Without explicit responsibilities, resources, and willingness to collaborate, deliberation is unlikely to enter budgeting, rule making, or service delivery [12].

Policy co-creation and participatory design supply this missing translation step. Co-design can enable diverse actors to define public problems jointly, explore the consequences of options, and develop policy prototypes, but closed administrative processes may constrain its institutional influence [13]. Research on co-production also shows that the number of participants is not a sufficient indicator of quality: evaluation should encompass process outputs, participants' experiences, and public-value outcomes [14][15]. In rural areas, research on agricultural knowledge and innovation systems (AKIS), living labs, and social innovation further shows that knowledge flows, intermediary organizations, mutual learning, legitimation, and sustained resources are conditions for institutionalizing innovation [16][17][18][19][20].

Against this background, the study addresses three questions. First, what participatory structures, scenario methods, and policy co-creation mechanisms have been used

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in recent evidence? Second, which mechanisms convert participation into policies that are executable and resilient? Third, how can this evidence be integrated into a co-creation process suitable for Chinese counties while managing risks of tokenistic participation, digital exclusion, and insecure data rights? The study does not assess the policy effects of an actual county, nor does it treat literature co-occurrence as causal. Its purpose is to provide a reproducible cross-case evidence synthesis and, on that basis, a design framework that can be tested in real counties. The article reviews the theoretical foundations and related work, describes the data and methods, reports evidence-mapping and priority-analysis results, and then discusses theoretical contributions, policy implications, and validation boundaries.

II. LITERATURE REVIEW

A. Participatory Scenario Analysis Converts Uncertainty into Shared Judgement

A principal strength of participatory scenario analysis is that it preserves irreducible uncertainty. Studies of rural towns in the United States, the European Union's rural 2040 foresight exercise, and cross-land-system reviews use contrasting futures to structure long-term policy dialogue rather than present a forecast as a certain answer [6][7][8]. High-quality scenario processes first make explicit how different actors value nature, quality of life, and development benefits, and then examine relationships among drivers. A Czech landscape study combined a values framework with the Three Horizons method, demonstrating that value differences are inputs to scenario design rather than noise to be removed after analysis [21]. A German food-systems study brought the institutional landscape, incumbent regimes, and innovation niches into a common analysis, allowing regional value chains and other innovations to be compared across futures [22].

Scenario methods are increasingly integrated with spatial and quantitative evidence. A study of the Colombian highlands connected planning materials, local visions, remote-sensing maps, field baselines, and ecosystem-service estimates in a seven-step process [9]. A Czech rural study juxtaposed quantitative scenarios and ethnographic knowledge to distinguish business-as-usual from community-transition pathways [10]. A Brazilian case used feedback loops to identify how urban expansion amplifies effects on nature's contributions to people [11]. These studies demonstrate that local knowledge and models are not substitutes. They must be mutually scrutinized through explicit assumptions, discussion of disagreement, and subsequent revision.

B. Policy Co-Creation Translates Scenario Narratives into Services and Rules

Policy co-creation refers to public institutions and affected groups jointly defining problems, developing options, testing prototypes, and participating in evaluation. Co-design can broaden participation and render the future consequences of policy choices visible, but its effects depend on whether policy processes permit external knowledge to alter agendas [13]. Research on rural local governments in Finland further shows that legal authority and funding are not the only constraints. Officials' role perceptions, boundary-spanning actors, public authorities' acceptance of institutional responsibility, and trusted collaboration platforms also determine whether co-creation can endure [23]. Accordingly, this study defines a policy prototype as a service process, allocation of

responsibilities, data rule, or resource arrangement that can be discussed and revised, rather than as a display artifact produced during a design exercise.

Co-creation also has a "dark side." A scoping review identifies power imbalances, inclusion gaps, resource constraints, inadequate rules, and risks to continuity [14]. Research in turbulent settings cautions that multi-strategy collaboration can strengthen adaptive capacity while also producing blurred responsibility and conflicts of legitimacy [24]. Measurement frameworks should therefore not merely count meetings, proposals, or participants, but distinguish process outputs, participant experience, and outcomes [15]. Representativeness, the experience of being heard, recorded dissent, traceable responsibility, and subsequent uptake must all be incorporated into evaluation.

C. Rural Innovation Depends on Knowledge Flows and Institutional Embedding

Agricultural innovation governance involves macro-institutions, governance systems, local conditions, actor capabilities, psychosocial factors, and innovation processes; it is therefore not a value-neutral process of technology diffusion [16]. AKIS research treats organizational relationships and knowledge flows among researchers, advisers, farmers, firms, and government as foundations for transformation [17]. Rural living labs provide an organizational setting for repeated collaboration and mutual learning. Their performance should be assessed through shared ownership, practical feasibility, learning, and contextual performance [18][20]. A longitudinal Slovenian case further indicates that network embedding, narrative resource mobilization, and public legitimation shape whether social innovation can persist [19].

Institutional embedding is especially important in digital and climate-adaptation settings. Research from the Central and West Asia and North Africa (CWANA) region shows that climate information, markets, finance, early warning, and extension services must be deployed as a portfolio; pilots face regulatory, financing, and capacity constraints when scaled [25]. A cross-sectional study in Ghana found that digital advisory services were associated with 12.4%, 4.2%, and 4.6% higher probabilities of adopting row planting, zero tillage, and drought-tolerant seeds, respectively, but these estimates cannot be generalized as long-term causal effects [26]. Research on farmer data further argues that individual privacy is insufficient to address collective risks. Data access, control, repurposing, and platform accountability must enter policy design [27].

III. RELATED WORK AND RESEARCH GAP

Existing approaches address future exploration, joint decision making, knowledge collaboration, and technology assessment separately, but their connections remain incomplete. Table I shows that participatory scenario analysis is strong at revealing uncertainty but often lacks implementation responsibility. Policy co-creation can produce prototypes but may understate external shocks. AKIS and rural living labs explain relational networks but typically do not rank alternative portfolios. Multi-criteria decision analysis (MCDA) can compare options transparently, but it may mistake the weights of a small number of experts for public preferences [28][29][30][31]. Chinese research has already provided county-panel, community-case, and configurational evidence [4][5][32][33][34], yet it still inadequately records

who defines indicators, who bears costs, who controls data, and how disagreement enters proposed arrangements.

TABLE I. RESEARCH APPROACHES, CONTRIBUTIONS, AND UNRESOLVED ISSUES.

Approach	Core contribution	Main limitation	Connection developed in this study
Participatory scenario planning	Compares multiple futures and makes values and uncertainty explicit	May remain at the level of vision; implementation responsibility is unclear	Converts narratives into policy prototypes and a responsibility matrix
Policy co-creation and co-design	Jointly defines problems and tests services and rules	May be absorbed by closed administrative processes	Establishes adoption checkpoints, dissent records, and responsible actors
AKIS and rural living labs	Explains knowledge flows, learning, and intermediary organizations	Lacks cross-scenario comparison of policy portfolios	Treats knowledge networks as scenario variables and implementation vehicles
Digital rural development and climate services	Provides evidence on technology adoption, regional differences, and configurations	Can overlook exclusion, collective data rights, and benefit distribution	Treats accessibility, rights, and benefit distribution as governance constraints
Q methodology and MCDA/DEMATEL	Makes viewpoints, weights, and influence structures visible	Expert weights may obscure disadvantaged groups	Identifies disagreement before transparent ranking and sensitivity analysis

This study places participatory scenario analysis at the front end of policy co-creation so that problem boundaries, value trade-offs, and uncertainty are made explicit before prototype design. It then connects service design, data governance, and the allocation of responsibility through a scenario–prototype–portfolio–feedback loop. Literature frequencies are not interpreted as effect sizes. Instead, they are converted into auditable evidence priorities and examined under multiple weighting schemes.

IV. RESEARCH METHODS

A. Research Strategy

The study uses a sequential explanatory evidence synthesis. The first phase quantitatively describes the literature by year, topic, region, method, and coded characteristics. The second phase applies qualitative thematic synthesis to explain how mechanisms connect to outcomes and under what conditions. The third phase translates mechanism evidence into policy tools and ranks them with multiple criteria. As shown in Figure 1, the process comprises five stages: scoping, coding, integration, prioritization, and framework translation. Each claim retains its source identifier, evidence type, region, and limit on generalization, thereby establishing a minimum audit trail.

Sequential Mixed-Method Evidence Synthesis



Audit rule: each claim retains source ID, evidence type, geography and transfer boundary

Fig. 1. Sequential mixed-methods evidence-synthesis process. Source: Prepared by the author from 36 verified sources.

B. Search Scope and Inclusion Rules

Structured searches covered six concept groups: participatory scenario planning, policy co-creation, rural innovation systems, digital agriculture and climate adaptation, mixed methods and MCDA, and Chinese county governance. The time window was 2021–2026. Sources had to meet three conditions: the title, author, year, and publication outlet could be verified through a publisher, DOI, or official government website; the content could inform method design, mechanism interpretation, or institutional boundaries; and the abstract or full text was sufficient to judge its scope of application. Unverifiable sources, duplicates, and studies concerned only with algorithms rather than rural or policy mechanisms were excluded. This process is a purposive evidence map, not an exhaustive systematic review; it therefore does not report invented search-hit counts or PRISMA exclusion counts.

C. Coding Framework

The unit of analysis was an individual source. Coding included contextual, mechanism, and outcome variables. Contextual variables comprised publication year, peer-review status, topic, region, method family, and whether the source directly addressed rural issues. Mechanism and outcome variables were binary-coded. A value of 1 was assigned only when a verified abstract or full text explicitly supported the relevant concept. The coding manual appears in Table II. After coding, scripts checked sample size, identifier uniqueness, year range, and the number of peer-reviewed sources; the results were then checked item by item against verification records. Because coding was completed by a single analyst, no unsupported inter-coder reliability coefficient is reported.

TABLE II. CODING MANUAL FOR MECHANISM AND OUTCOME VARIABLES.

Type	Variable	Operational definition
Mechanism	Inclusive participation	Explicitly addresses representation, disadvantaged groups, power, or accessibility
Mechanism	Knowledge integration	Connects local knowledge, scientific data, spatial information, or cross-actor knowledge flows
Mechanism	Policy prototyping	Converts visions into service processes, rules, roles, tasks, or pilots
Mechanism	Portfolio selection	Compares multiple scenarios, policy-tool portfolios, weights, or trade-offs
Mechanism	Institutional embedding	Connects to formal policy cycles, organizational responsibility, resources, or sustained monitoring
Outcome	Legitimacy	Addresses procedural fairness, recognition, trust, rights, or acceptability
Outcome	Learning	Addresses shared understanding, capability, reflection, or knowledge exchange
Outcome	Executability	Addresses tasks, resources, organizational arrangements, or conditions for implementation
Outcome	Adoption	Addresses adoption and continued use of policies, services, or technologies
Outcome	Resilience	Addresses ecological, climatic, land, governance, or organizational adaptive capacity

D. Co-Occurrence Analysis and Thematic Synthesis

The mechanism–outcome co-occurrence matrix describes the number of instances in which two codes appear in the same source. Let the code for source i on mechanism m be $\$M_{im}\$$ and the code on outcome o be $\$O_{io}\$$. The co-occurrence count is:

$$C_{mo} = \sum_{i=1}^{36} M_{im} O_{io} \quad (1)$$

Co-occurrence indicates only that two concepts are discussed together in the literature; it does not represent a statistical correlation or a causal effect. The qualitative synthesis further examined the evidence type, geographic setting, and counterexamples for each frequent co-occurrence. It distinguished claims that are usable for design, claims of association, and claims supported by causal identification.

E. Policy-Tool Priorities and Sensitivity Analysis

The thematic synthesis produced six policy tools: inclusive access and capacity building; farmer data rights and governance; multichannel climate advisory services; agricultural socialized-service organizations; participatory monitoring and feedback; and digital infrastructure and platforms. Four normalized indicators on a 0–1 scale were calculated for each tool. Evidence coverage was the number of supporting sources divided by the maximum number supporting any of the six tools. Geographic breadth was the number of represented regional categories divided by the maximum number of regions. Implementation depth was the mean of the policy-prototyping, institutional-embedding, and executability codes. Risk control was the mean of the inclusion, institutional-embedding, and legitimacy codes. The score for option j under weighting scenario s was:

$$P_j^{(s)} = 100 \sum_{k=1}^4 w_k^{(s)} x_{jk}, \sum_{k=1}^4 w_k^{(s)} = 1 \quad (2)$$

The balanced weights were 0.30, 0.25, 0.25, and 0.20, respectively. Evidence-first, equity-first, and execution-first scenarios each increased the weight of the corresponding criterion. These scores are transparent evidence priorities, not policy returns or intervention effect sizes.

V. DATA

The final corpus comprised 36 sources published between 2021 and 2026. Thirty-three peer-reviewed articles accounted for 91.7%, while three official reports or policy documents accounted for 8.3%. Thirty sources directly concerned rural, agricultural, or county-level issues, accounting for 83.3%; 23 explicitly used participatory or co-creation concepts, accounting for 63.9%. Regional coding included 11 European sources, 8 cross-regional reviews, 7 Chinese sources, 4 African sources, 2 Latin American sources, and 1 each for CWANA, global, Global South, and North America. The largest number of sources was published in 2024 (13), followed by 2022 (8), 2023 (7), 2021 and 2025 (3 each), and 2026 (2). The thematic and annual distributions are shown in Figure 2.

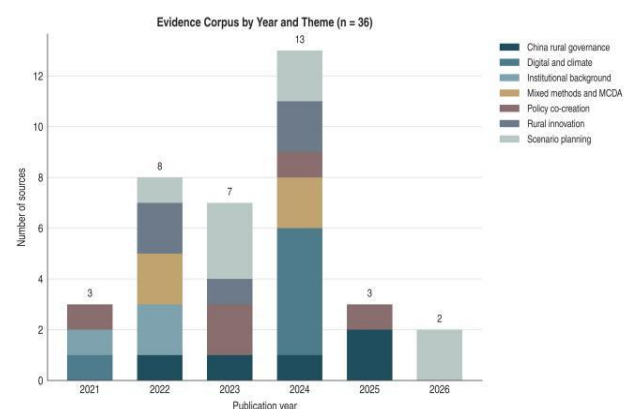


Fig. 2. Annual and thematic distribution of the evidence corpus (n=36).

Data preprocessing was limited to de-duplication, harmonization of formal issue years, topic consolidation, and binary coding. The article by Rodríguez et al. on scenario planning in the Colombian Andes was retrieved in multiple thematic searches but retained only once [9]. When an online-first year differed from the formal volume-and-issue year, the latter was used. Missing DOIs occurred only in policy

documents with official links, and no core coding values were missing. All fields, source identifiers, and calculated results were saved as CSV files to permit verification and replacement.

VI. RESULTS

A. The Evidence Focus Shifts from Inviting Participation to Embedding Implementation

The co-occurrence matrix shows that institutional embedding and executability co-occurred 26 times, the highest frequency among all 25 mechanism–outcome combinations. Policy prototyping and executability co-occurred 23 times, while institutional embedding and resilience co-occurred 22 times. Knowledge integration and portfolio selection each co-occurred with resilience 19 times. This distribution indicates that the evidence consistently links sustained resources, organizational responsibility, and policy-cycle connections to the movement from deliberation to implementation. Diverse knowledge or multiple options alone are unlikely to generate sustained action when no institutional arrangement receives them (Figure 3).

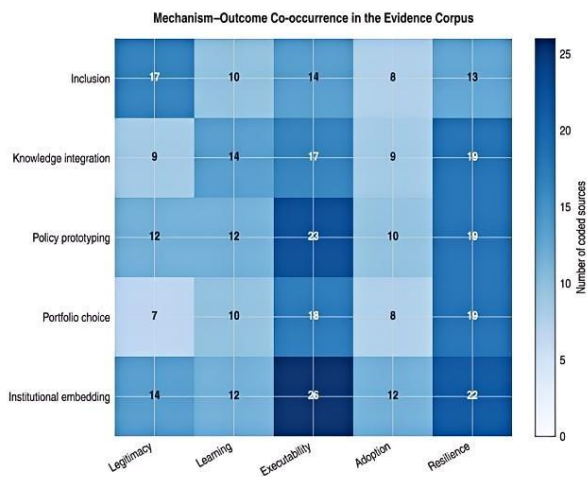


Fig. 3. Mechanism–outcome co-occurrence matrix. Each cell reports the number of the 36 sources in which the corresponding mechanism and outcome both occur; co-occurrence does not imply a causal effect.

Inclusive participation co-occurred with legitimacy 17 times, with executability 14 times, and with resilience 13 times. This pattern suggests that inclusion primarily performs a procedural and rights-based function while also influencing whether relevant actors take up a proposed arrangement. In contrast, all mechanisms had relatively low co-occurrence with adoption: institutional embedding appeared 12 times, policy prototyping 10 times, knowledge integration 9 times, and both inclusion and portfolio selection 8 times. This does not mean participation is ineffective. Rather, most studies remain at the level of design, case interpretation, or cross-sectional association, and there is limited longitudinal evidence on the adoption of actual policies, services, and technologies.

B. Five Mechanism Chains Derived from the Evidence

The first is the inclusion–legitimacy chain. When representation, power, and accessibility are explicitly addressed, participation is more likely to generate procedural recognition. A review of Q methodology in the Global South observes that women and individuals with weaker social ties are more likely to be absent from recruitment [29]. The

Chengdu case further calls for older farmers and women to enter digital-governance feedback loops [33]. Inclusion is thus not a post-event statistic; it is a continuous design question encompassing recruitment, expression, uptake of proposals, and the recording of dissent.

The second is the knowledge integration–resilience chain. Combining local narratives with remote sensing, field baselines, ecosystem services, or systems feedback allows policy options to be examined under different shocks [9][10][11]. AKIS extends this integration into sustained knowledge flows among research, extension, farmers, and firms [17]. The value of this chain lies in exposing assumptions and conflicts, not in using models to replace local judgement.

The third is the prototype–executability chain. A strategy enters policy design only when it is translated into service touchpoints, data rules, responsible actors, and resource conditions [12][13]. Living labs support this translation through iterative collaboration and phase-based reflection [18][20]. In this study, a prototype is therefore defined as a minimum viable institutional arrangement rather than a graphical output.

The fourth is the portfolio–robustness chain. No single tool is optimal across all rural settings. Multi-criteria research calls for transparent objectives, weights, costs, and uncertainty [30][31], while research on Chinese pilots shows that social and technical conditions can generate governance effectiveness through multiple configurations [5]. Portfolio selection must therefore retain disagreement and stress-test options across multiple futures.

The fifth is the embedding–continuity chain. Public-sector readiness, boundary-spanning intermediaries, sustained financing, and monitoring determine whether innovation can extend beyond a one-off project [19][23]. Provincial evidence on agricultural socialized services and cultivated-land resilience indicates that service organizations can connect smallholders, green efficiency, and scale conditions [34]. However, availability, benefit distribution, and responsibility at county and village levels still require observation during co-creation.

C. Policy-Portfolio Priorities and Sensitivity

Under balanced weights, participatory monitoring and feedback scored 84.67 and ranked first. Farmer data rights and governance scored 75.19, and inclusive access and capacity building scored 72.17, ranking second and third, respectively. Digital infrastructure and platforms, agricultural socialized-service organizations, and multichannel climate advisory services scored 61.70, 61.44, and 54.48. Participatory monitoring and feedback remained first across all four weighting schemes, with scores from 84.00 to 87.89, indicating that this conclusion does not depend on one value configuration (Table III).

TABLE III. PRIORITY OF SIX POLICY TOOLS AND SENSITIVITY TO WEIGHTING SCHEMES.

Policy tool	Supporting sources	Regions	Balanced weights	Evidence first	Equity first	Execution first
Participatory monitoring and feedback	15	4	84.67 (1)	87.89 (1)	84.00 (1)	84.89 (1)
Farmer data rights and governance	7	6	75.19 (2)	69.10 (3)	78.86 (2)	75.76 (2)
Inclusive access and capacity building	10	6	72.17 (3)	71.00 (2)	72.67 (3)	65.50 (4)
Digital infrastructure and platforms	9	4	61.70 (4)	61.44 (4)	59.41 (5)	62.37 (5)
Agricultural socialized-service organizations	6	3	61.44 (5)	56.89 (5)	63.56 (4)	71.33 (3)
Multichannel climate advisory services	7	4	54.48 (6)	52.90 (6)	53.14 (6)	54.57 (6)

Note: Numbers in parentheses are ranks under the same weighting scheme. Scores are derived from evidence coding and explicit weights; they are not intervention effect sizes (Figure 4).

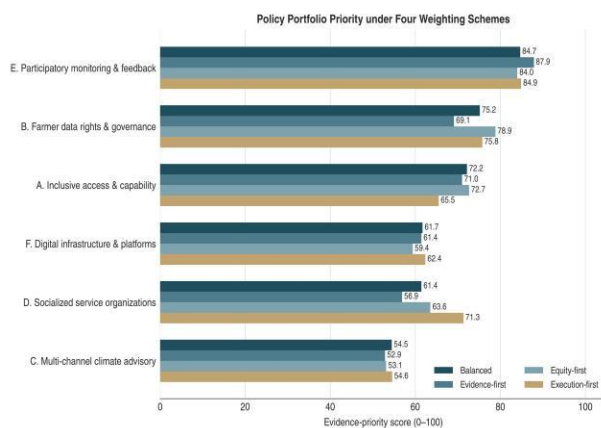


Fig. 4. Policy-portfolio priorities under four weighting schemes.

The sensitivity analysis also reveals two structural differences. Inclusive access ranks second in the evidence-first scenario but fourth in the execution-first scenario, suggesting that relevant literature spans regions yet less often provides deep evidence on organizational implementation. Agricultural socialized services rise from fifth to third in the execution-first scenario, reflecting more concrete organizational and delivery mechanisms but narrower cross-regional evidence. Multichannel climate advisory services rank sixth in all four schemes. This does not imply that they are unimportant; rather, an advisory channel alone cannot

substitute for access capacity, data rights, service organizations, and feedback institutions.

D. The Scenario-Prototype-Portfolio-Feedback Framework

The synthesis yields the closed loop shown in Figure 5. The scenario stage compares values, shocks, and trade-offs. The prototype stage translates choices into services, rules, roles, resources, and data rights. The portfolio stage uses MCDA to compare robustness, distributional effects, and costs. The feedback stage returns from pilots, monitoring, adoption, and learning to the next round of scenarios. Representation, power, transparency, accessibility, and traceability operate across all four stages as governance guardrails.

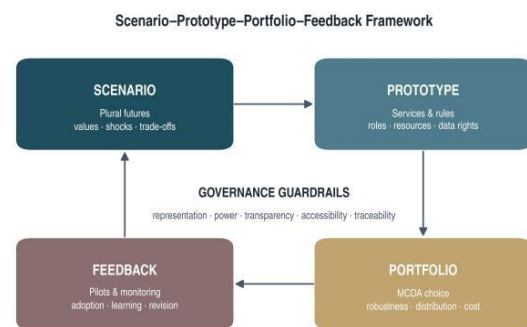


Fig. 5. Scenario-prototype-portfolio-feedback framework for policy co-creation.

VII. DISCUSSION

A. Theoretical Contribution: Reframing Participation from a Procedural Variable to a Design Infrastructure

The first contribution is to distinguish between participation occurring and participation making a difference. Prior research often treats participation as an attribute of workshops or consultation. This study disaggregates it into five traceable mechanisms. Inclusion provides an entry point to legitimacy; knowledge integration establishes a cognitive basis; policy prototyping completes institutional translation; portfolio selection makes value trade-offs explicit; and institutional embedding creates sustained feedback. This logic explains why institutional embedding-executability and prototype-executability have the highest co-occurrence, and why adoption evidence is generally sparse. Participation can only plausibly influence behavioral outcomes when it enters policy cycles through organizational responsibility, resources, and feedback.

Compared with work that uses dynamic SWOT and pairwise comparison to identify priority factors [35], the present study retains the advantage of translating qualitative judgement into transparent ranking but changes the object and logic of analysis. Dynamic SWOT principally compares the importance of predetermined factors. This study first develops multiple futures, then creates policy prototypes, compares portfolios, and establishes feedback. This approach can address interdependencies among technological, commercial, cultural, and governance conditions while avoiding the treatment of strengths, weaknesses, opportunities, and threats as static categories.

B. Practical Implications: County Policy Requires Portfolios Rather Than Isolated Projects

Participatory monitoring and feedback, rather than digital infrastructure, rank first in the policy priority analysis. This finding does not negate investment in networks or platforms. It indicates that infrastructure is more likely to generate sustained public value when embedded in feedback, service responsibility, and revision rules. China's digital rural development policy already advances infrastructure, smart agriculture, digital governance, public services, and farmers' digital literacy in parallel [36]. County implementation can organize these tools in three layers: a foundation that protects access and data rights; a middle layer that delivers through socialized services and multichannel advisory systems; and an upper layer in which participatory monitoring determines whether to expand, pause, or adjust a policy.

Farmer data rights rank second, indicating that the policy boundary of digital innovation is shifting from whether a platform exists to who can access, interpret, and benefit from data. If platforms default to rights of extended use, disadvantaged farmers may lose control over production data and collective interests even when they are invited to workshops [27]. The prototype stage should therefore map both a service blueprint and a data-flow diagram, identifying data sources, purposes, retention periods, sharing entities, withdrawal mechanisms, and complaint pathways.

Agricultural socialized services rise substantially under execution-first weights, indicating their organizational potential to convert policy portfolios into everyday services. Counties can establish multichannel delivery through village collectives, cooperatives, agricultural extension organizations, and market actors, but service outsourcing should not be equated with co-governance. Real-world pilots should record access costs, frequency of use, and benefit distribution for farmers with different farm sizes, genders, ages, and digital capacities, and should return these differences to the next scenario-revision cycle.

C. An Implementable Co-Creation Protocol

At county level, application can proceed through stakeholder mapping, a jointly developed baseline, identification of disagreements, construction of multiple scenarios, policy prototyping and portfolio appraisal, and then small-scale pilots and periodic review. At a minimum, prototypes should specify service processes, responsibilities, resources, and data rules. Evaluation should report sensitivity to weights and preserve minority views. Monitoring should cover adoption, withdrawal, complaints, budgets, and ecological-livelihood outcomes. This protocol is consistent with the policy-cycle embedding emphasized in European Union methods [37] and compatible with the multi-tool policy boundaries of China's digital rural development agenda [36].

D. Limitations

This study uses a purposive sample rather than an exhaustive systematic review, and English-language journals and publicly available materials are more readily included. Binary coding enables comparison but loses variation in participation depth and evidence quality, while co-occurrence counts cannot establish effect direction or causal relations. Coding was completed by one analyst, without an independent double-coding reliability assessment. MCDA weights are used only for sensitivity analysis and do not represent the

preferences of actual counties. In formal applications, local participants must redefine criteria, weights, and thresholds.

VIII. CONCLUSION

Using 36 public sources published from 2021 to 2026, this study develops and examines a scenario-prototype-portfolio-feedback framework for policy co-creation. The evidence synthesis indicates that the value of participatory scenario analysis is not the production of a static vision. It lies in making values and uncertainty explicit, connecting local knowledge with analytical evidence, translating strategies into responsibilities and rules, and revising them through institutionalized feedback. Institutional embedding and executability have the strongest co-occurrence. Participatory monitoring and feedback rank first consistently under four weighting schemes, while data rights and inclusive capacity building have higher overall priority than expanding digital infrastructure in isolation.

Theoretically, the study advances participation from a procedural input to a design infrastructure for rural innovation and connects scenario planning, policy co-creation, AKIS, and MCDA. Practically, counties should not substitute isolated digital projects for governance design. They should instead build a portfolio that includes access protection, data rights, service organizations, policy prototypes, and feedback-based revision. The results are a reproducible cross-case evidence synthesis, not the estimated effect of an intervention in any particular county. Future research should conduct preregistered multi-case validation across different county types, using real workshop records, participant networks, policy adoption, service use, and ecological-livelihood indicators. It should compare the incremental value of the co-creation framework against conventional consultation and follow at least one complete policy cycle.

Data Availability, Ethics, and Conflict of Interest Statement.

This study uses publicly published literature and policy documents and does not involve personal data, human participants, or animal experiments; no additional ethics approval was required. The coded data, mechanism-outcome matrix, policy-priority calculation sheet, analytical scripts, and high-resolution figures are provided with the article. The study received no external funding, and the author declares no conflict of interest. Any formal county-level field research should separately complete ethics review, informed consent, protection of sensitive information, and arrangements for farmer data rights.

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