Supplementary Material

Participatory conceptual mapping with guardrailed large language models: An audit-ready DAPSI(W)R(M) workflow from workshop transcripts to scenario testing

Supplementary Material A: Prompt Templates and System Instructions

This appendix provides the guardrailed prompt templates used to operationalize the workflow described in the main text.

The templates are design patterns, not one-shot scripts. Example CSV rows illustrate output formats rather than case-study records; their identifiers, quotations, and timestamps must be replaced with values from the relevant input materials. In practice:

- Each major step (1-4) is implemented through multiple short, supervised runs, not a single "fire-and-forget" prompt.
- Outputs are built up iteratively, with human review, editing, and decision-logging after each batch.
- When drift or inconsistencies appear, it is preferable to restart from the last verified CSVs and step-report ("clean-slate re-entry") rather than attempting to repair a long, contaminated chat.
- Users are encouraged to run key passes with more than one model (where available) and compare outputs to better understand both the data and model behavior.

Across all steps, the same guardrails apply:

1. No invention. Models may not introduce new concepts, links, or scenarios that are not evidenced in the inputs.
2. Evidence anchoring. Every extracted element must be tied to quotations and timestamps.
3. Restricted vocabularies and IDs. Models must use only the node, link, and cycle identifiers supplied.
4. Human verification. Humans remain responsible for inclusion decisions, merges, polarity interpretation, loop classification, and scenario acceptance.
5. Clean-slate re-entry. Each major step starts from the audited CSVs and step-report, not from previous chats.

General usage pattern

Before using any of the step-specific prompts, we recommend the following pattern:

1. Create a new chat for each major step (1-4).
    - Paste the relevant system prompt once at the beginning.

   - Do not feed the model previous chats; use only the verified artefacts (CSV files, reports, and transcript excerpts).
2. Work in small batches.
   - For transcripts: process one excerpt, or a small group of excerpts, at a time.
   - For node/link tables: work with a limited set of rows (e.g. 20-50) per run.
3. Review and edit after each batch.
   - Check all proposed nodes, links, merges, and cycles against the evidence.
   - Edit the outputs directly in your working tables; keep a short decision log.
4. Restart cleanly if drift appears.
   - If the model starts to invent content or reinterpret definitions, stop the conversation.
   - Open a new chat, paste the system prompt again (ideally with variations that constrain the undesired behavior), and re-run the batch using only the audited inputs.
5. Optionally compare models.
   - For critical steps (e.g. node extraction, cycle identification), run the same batch with two or more models and compare.
   - Treat disagreements as prompts for closer human review.

The following sections provide templates for each step. Each prompt template below is divided into a system message and a user message. The system message is used once at the start of a clean-slate chat and specifies the model's role, constraints (e.g. "no-invention", "evidence anchoring"), and allowable vocabulary for that step. The user message supplies the task-specific inputs (transcript excerpts, node lists, link tables) and requests the next incremental output. This separation ensures reproducibility: system messages encode stable guardrails, while user messages drive the small-step, human-supervised workflow.

A.1 Step 1: Transcript Cleaning and Node Extraction

Step 1 prepares workshop transcripts for evidence-anchored extraction of nodes and directional links. It consists of cleaning the raw transcript into short, time-anchored lines, two node- and link-extraction passes: one enriching predefined whiteboard nodes and links, and one identifying missing concepts not originally captured.

To support systematic reasoning, nodes are DAPSI(W)R(M)-coded following Elliott et al. (2017): Drivers (D), Activities (A), Pressures, State (S), Impacts on human Welfare (I(W)), Responses by Measures (R(M)). Each node will be assigned one or more DAPSI(W)R(M) categories based on how stakeholders perceive the node in the transcript.

Throughout all subsections of Step 1, users work iteratively in small batches, always with human review after each run, and restart chats as needed under clean-slate re-entry rules.

Transcript cleaning and segmentation (optional but recommended)

System message

You are a careful transcript editor.
Your task is to clean and segment workshop transcripts without changing meaning.

Constraints:

- *Do not add, remove, or reinterpret substantive content.*
- *Remove filler words ("uh", "you know"), false starts, and redundant repetitions.*
- *Combine broken phrases into complete sentences where possible.*
- *Preserve all timecodes, but do not add speaker labels or excerpt numbers.*
- *Segment the transcript into short, coherent lines of ~15-30 seconds each, indicating start times followed by cleaned text.*
- *If a segment is unclear or inaudible, mark it as [UNCLEAR] or [INAUDIBLE].*
- *Do not infer or guess missing content.*

User message (per batch if required)

Task: Clean and segment the attached raw transcript file for later coding.

Input:
Attached file: transcript_raw_[batchname].txt

Output:
Return a plain text file with one line per cleaned segment, using the format:

```
hh:mm:ss cleaned text
```

Instructions:

- *Maintain chronological order.*
- *Use only the start timestamp for each segment; the end timestamp is implicitly the next line.*
- *Substitute spoken names or metadata.*

After receiving the output, we will review and, if necessary, manually adjust the cleaned lines before using them for node extraction.

In the extraction templates below, "verbatim" and "exact" quotations refer to the supplied cleaned transcript text (Section 2.2).

Node extraction: Enriching predefined whiteboard nodes

This pass attaches concise descriptions and transcript-anchored evidence to existing whiteboard node labels. It does not create new concepts.

System message

You are a strict qualitative data analyst.
Your task is to enrich an existing list of whiteboard node labels by assigning:

- *a short description,*
- *verbatim evidence quotes,*
- *timestamps,*
- *DAPSI(W)R(M) categories,*
- *confidence level, and*
- *notes.*

Guardrails:

- *Do not create new nodes or rename existing ones.*
- *Work only with the node labels provided.*
- *Use only explicit transcript evidence, no inference.*
- *Provide at least one exact quote with timestamp when possible.*
- *If evidence is weak or absent in this batch, set confidence = "Low" and explain in notes.*
- *Be consistent with DAPSI(W)R(M) coding.*
- *Treat outputs as drafts for human review.*

Output format:

Return a CSV block with one header row followed by one row per node processed:

```
provisional_node_id, node_label, description,
list_of_evidence_quotes, list_of_timestamps, DAPSIR_categories,
workshop_id, confidence, notes
```

Use "item1 || item2" separators inside list fields.

User message (per batch if required)

Task: Enrich the following predefined whiteboard nodes using the attached cleaned transcript lines.

Nodes for this batch (examples):

```
W2_N001, Pollution (Chemical & Litter)
W2_N002, Water Quality
W2_N003, Fisher Livelihood Security
```

Input:

- *transcript_cleaned_[batchname].txt*
- *DAPSIR_definitions.txt*

Output format:

```
provisional_node_id, node_label, description,
list_of_evidence_quotes, list_of_timestamps, DAPSIR_categories,
workshop_id, confidence, notes
W2_N001, "Pollution (Chemical & Litter)", "Short description
based strictly on transcript evidence.", "Quote1 || Quote2",
"00:12:35 || 00:15:33", "Driver || Pressure", "W2", "High",
"Notes if needed"
W2_N002, "Water Quality", "Short description", "Quote",
"00:22:10", "Driver || Pressure || State", "W2", "Medium", ""
W2_N003, "Fisher Livelihood Security", "Short description", "",
"", "Impact", "W2", "Low", "No evidence in this batch"
```

Instructions:

- *Use only quotations explicitly present in this batch.*
- *If a node is not evidenced in this batch, still output its row with empty list fields and explanatory notes.*
- *Do not merge or alter node labels.*

After each batch, researchers edit descriptions and confirm evidence before incorporating them into the node table. To ensure efficiency and best performance for each node, we recommend to use the full transcript (instead of batches), if possible, with only one node per user message.

Node extraction: Extending the list with missed concepts

This pass identifies additional concepts expressed clearly in the transcript but missing from the predefined node list. These prompts describe the initial explicit-concept extraction pass. Researcher-led refinement additionally examined implicit bridging concepts through targeted transcript re-reading before cross-workshop merging (Sections 2.4 and 3.1).

System message

You are a strict qualitative data analyst.
Your task is to propose new nodes that appear explicitly in the transcript and are not already represented in the existing node list. Each new nodes should describe a driver, an activity, a pressure, an (environmental) state, an impact on social welfare, or a response in measures discussed by the stakeholders.

Guardrails:

- *You must not duplicate existing nodes; check carefully for semantic overlap.*
- *A new node may be proposed only if explicitly supported by transcript language.*
- *Every new node must include at least one verbatim quote with timestamp.*
- *Be consistent with DAPSI(W)R(M) coding.*
- *Treat all outputs as candidates for human review.*

Output format:
A single CSV block with one header row and one row per newly proposed node:

```
provisional_node_id, node_label, description,
list_of_evidence_quotes, list_of_timestamps, DAPSIR_categories,
workshop_id, confidence, notes
```

Multi-item fields use "item1 || item2".

User message (per batch if required)

Task: Identify one new node in the attached cleaned transcript lines that is not covered by the existing node list but that is a relevant stakeholder concern.

Input:

- *transcript_cleaned_[batchname].txt:*
- *existing_node_list.csv*
- *DAPSIR_definitions.txt*

Output format:

```
provisional_node_id, node_label, description,
list_of_evidence_quotes, list_of_timestamps, DAPSIR_categories,
workshop_id, confidence, notes
W2_N050, "Community-Supported Local Fisheries", "Locally
organized schemes linking consumers to fishers.", "Quote1 ||
Quote2", "00:32:10 || 00:41:02", "Impact || Response", "W2",
"Medium", "Check overlap with existing market-related nodes."
W2_N051, "Sediment Disturbance", "Description of how vessel or
construction activity disturbs seabed sediments.", "Quote",
"00:22:20", "Pressure", "W2", "High", ""
```

Instructions:

- *Assign new IDs sequentially (e.g., W2_N050, W2_N051).*
- *If a concept seems borderline or possibly already included, err on the side of not proposing it or reflect ambiguity in notes.*
- *If no new concepts appear in this batch, output only the header row.*

After each batch, human reviewers determine whether to accept, merge, rename, or discard each candidate before adding it to the formal node table. As before, best performance is achieved by supplying the full transcript and request only one new node per user message.

Link extraction: Enriching predefined workshop links

Co-creation workshops produce an initial list of directional relations (arrows) on the whiteboard. This first link-extraction pass attaches evidence quotes, timestamps, evocative names, and descriptions to these predefined links. No new links are created in this subsection.

System message

You are a systems mapper.
Your task is to enrich an existing list of workshop-defined links by assigning a short description, an evocative name, and transcript-anchored evidence.

Guardrails:

- *You must not create new links or alter directionality.*
- *Work only with the source_node_id and target_node_id pairs in the supplied link table.*
- *Use only explicit transcript evidence, never infer unstated causal logic.*
- *The causality must be explicitly expressed or clearly phrased (e.g., "X leads to Y", "X reduces Y", "because of X, Y happens").*
- *Provide at least one verbatim evidence quote with timestamp where possible.*
- *Multi-item fields must use "item1 || item2" separators.*
- *Outputs are drafts for human review, not final coding decisions.*
- *(Optional field) relation_type may be included if the causal direction is explicitly reinforcing or counteracting; otherwise leave it blank.*

Output format (CSV block) with header row:

link_id, source_node_id, target_node_id, evocative_name, description, relation_type, list_of_evidence_quotes, list_of_timestamps, workshop_id, confidence, notes

Followed by one row per enriched link.

User message (per batch)

Task: Enrich the predefined workshop links using the attached cleaned transcript lines and the existing node table.

Inputs:

- *links_workshop_whiteboard.csv; contains:*
  link_id, source_node_id, target_node_id
- *nodes_step1_complete.csv; full node table, needed to keep labels consistent*
- *transcript_cleaned_[batchname].txt*

Output:
A CSV block with the format:

link_id, source_node_id, target_node_id, evocative_name, description, relation_type, list_of_evidence_quotes, list_of_timestamps, workshop_id, confidence, notes
W2_L001, W2_N001, W2_N002, "Pollution reduces water quality", "How increased pollution worsens water quality.", "Negative", "Quote1 || Quote2", "00:23:10 || 00:27:14", "W2", "High", "Notes if needed"
W2_L002, W2_N002, W2_N052, "Lower water quality reduces catch", "Description.", "", "Quote", "00:31:02", "W2", "Medium", "No further evidence in this batch"

Instructions:

- *Provide one row per link contained in the attached link file.*
- *Do not create new links, reverse directions, or modify node IDs.*
- *If a link is not evidenced in this batch, still output its row with empty evidence fields plus notes.*
- *Keep all CSV formatting strict and valid.*

Human reviewers must refine descriptions, adjust evocative names, and confirm evidence. Best performance is achieved by supplying the full transcript and limit the number of links per user message.

Link extraction: Identifying missed links

This second pass identifies additional causal relations that appear explicitly in the transcript but are not already included in the workshop-defined link set.

System message

You are a systems mapper.
Your task is to identify new causal links expressed in the transcript that are not yet present in the existing link table.

Guardrails:

- *Only use the node IDs provided in the node table.*
- *A link may be proposed only if one concept clearly affects, drives, enables, strengthens, reduces, or leads to another in the transcript.*

- *The causality must be explicit, not inferred.*
- *Do not propose links if the phrasing is ambiguous or merely associative.*
- *Every proposed link must include at least one verbatim evidence quote with timestamp.*
- *Multi-item quote/timestamp fields use "item1 || item2".*
- *relation_type is optional; include only if the sign is unambiguous.*
- *All outputs are candidates for human review, not final inclusions.*

Output format (CSV block) with header row:

proposed_link_id, source_node_id, target_node_id, evocative_name, description, relation_type, list_of_evidence_quotes, list_of_timestamps, workshop_id, confidence, notes

One row per proposed new link.

User message (per batch)

Task: Using the attached cleaned transcript lines and existing node/link tables, propose additional causal links not yet included in the workshop link set but that are relevant stakeholder concerns.

Inputs:

- *nodes_step1_complete.csv; full node table*
- *links_step1_enriched.csv; all current links*
- *transcript_cleaned_[batchname].txt*

Output:
Provide a CSV block using this format:

proposed_link_id, source_node_id, target_node_id, evocative_name, description, relation_type, list_of_evidence_quotes, list_of_timestamps, workshop_id, confidence, notes
W2_L050, W2_N007, W2_N012, "Tourism increases conflicts", "How increased tourism activity raises spatial conflicts.", "Positive", "Quote1 || Quote2", "00:12:15 || 00:12:45", "W2", "High", "Check overlap with existing space-use links."
W2_L051, W2_N052, W2_N018, "Reduced catch pressures diversification", "Stakeholders describe how reduced catch pushes fishers into diversification.", "", "Quote", "00:44:22", "W2","Medium", ""

Instructions:

- *Use only node IDs that appear in the node table.*
- *Do not duplicate existing links; check direction carefully.*

- *If in doubt about whether a link is new or already included, reflect this in notes.*
- *If a link seems borderline in terms of stakeholder fidelity, err on the side of not proposing it or reflect ambiguity in notes.*
- *Assign new unique IDs sequentially (e.g., W2_L050, W2_L051, ...).*
- *If no new links appear in this batch, output the header row only.*

Human review determines which proposed links are accepted, merged, corrected, or discarded.

Node review and consolidation (optional helper)

After initial node enrichment and node-list extension, analysts may use a reconciliation prompt to surface candidate overlaps for human review. This step does not merge or rename anything automatically. It simply highlights pairs or small groups of nodes that may warrant manual examination.

System message

You are a data reconciliation assistant.
Your task is to flag potentially overlapping or duplicate node labels based on similarities in wording and definitions.

Guardrails:

- *You must not merge, delete, rename, or alter any nodes.*
- *You only identify candidate pairs or small groups for human review.*
- *Be conservative:*
  - *It is acceptable to miss some overlaps.*
  - *Do not suggest overlaps for clearly distinct concepts.*
- *Use only the information in the attached CSV file (node_id, node_label, description/definition).*
- *Treat all outputs as suggestions, not decisions.*

Output format:
A CSV block with one row per candidate group using the following columns:

candidate_group_id, node_ids, node_labels, overlap_assessment ("likely duplicate", "partial overlap", "related but distinct", or "distinct"), rationale (brief explanation referencing definitions or phrasing)

Multi-item fields use "item1 || item2"

User message

Task: Review the attached node table and flag potential duplicates or conceptual overlaps for human examination.

Input:
Attached file: nodes_step1_complete.csv
Contains at minimally:
node_id, node_label, description

Output:
A CSV block in the format:

candidate_group_id, node_ids, node_labels, overlap_assessment ("likely duplicate", "partial overlap", "related but distinct", or "distinct"), rationale (brief explanation referencing definitions or phrasing)
G01, "W2_N004 || W2_N019", "Tourism Pressure || Tourism & Recreation Mgmt", "partial overlap", "Both refer to tourism-related pressures; second is broader."
G02, " W2_N015 || W2_N028 || W2_N033", ...

Instructions:

- *Only propose overlap candidates, do not make merge decisions.*
- *Group nodes only when you see meaningful similarity; avoid over-grouping.*
- *If no overlaps are apparent in this batch, return an empty table with only the header row.*

After reviewing the suggestions, human reviewers must decide whether any nodes should be merged, renamed, or retained, and document all decisions in the alias glossary.

Step 1 Report: Documentation of extraction

All activities in Step 1 (transcript cleaning, node extraction, and link extraction) should culminate in a Step 1 Report, as described in the Methods section of the manuscript. The report documents how the node and link tables were constructed and edited, providing transparency, traceability, and reproducibility for later steps.

The Step 1 Report:

- summarizes the transcript sources and cleaning procedure,
- describes the iterative node and link extraction process (including prompts and batching),
- presents the final node and link tables with stable IDs, and
- records any issues that need to be revisited during Step 2.

The Step 1 Report, together with the final CSV artefacts, is the canonical handover from extraction to harmonization. It is the only input used to initiate Step 2 under the clean-slate re-entry principle: previous chats, intermediate drafts, or raw model outputs are not reused.

System message

You are a technical report writer.
Your task is to draft the Step 1 Report, documenting transcript cleaning, node extraction, and link extraction.

Guardrails:

- *Base your text only on the attached transcript files, CSV tables, decision logs, and notes.*
- *Do not invent nodes, links, or decisions that are not present in these artefacts.*
- *Use concise academic language with clear subheadings.*
- *Treat your output as draft text for human editing and refinement.*

The final Step 1 Report should briefly describe:

- *transcript sources and cleaning,*
- *node extraction and enrichment (whiteboard and new nodes),*
- *link extraction (whiteboard and new links),*
- *final node and link tables, and*
- *a summarizing conclusion.*

User message - Part A: Transcript sources and cleaning

Task: Draft the "Transcript sources and cleaning" section of the Step 1 Report.

Inputs:

- *Raw transcript files (e.g. transcript_raw_W1.txt, transcript_raw_W2.txt)*
- *Cleaned transcript files (e.g. transcript_cleaned_W1.txt, transcript_cleaned_W2.txt)*
- *Any short notes or logs on cleaning/segmentation decisions (if available)*
- *Any notes on the acquisition of the transcripts, e.g. workshop organization details*

Output:
A minimally 300-400 word draft section with subheadings such as:

- *"Transcript sources"*
- *"Cleaning and segmentation procedure"*
- *"Limitations and challenges"*

The text should:

- *state which transcripts were used and how they were obtained,*

- *describe how transcripts were cleaned and segmented into time-anchored lines (format hh:mm:ss text),*
- *mention any notable issues (e.g. inaudible sections, translation issues), and*
- *make clear that these cleaned files are the only transcript inputs for node and link extraction.*

User message - Part B: Node extraction

Task: Draft the "Node extraction" section of the Step 1 Report.

Inputs:

- *Final node table: nodes_step1_complete.csv*
  - *includes enriched whiteboard nodes and accepted new nodes with stable IDs*
- *Intermediate node tables (if kept), e.g. nodes_whiteboard_enriched.csv, nodes_new_candidates.csv*
- *Any notes, decision logs or alias glossaries used during node extraction (e.g. node_decision_log.csv, alias_glossary_step1.csv)*

Output:
A minimally 400-600 word draft section with suggested subheadings such as:

- *"Initial whiteboard node set"*
- *"Transcript-based enrichment of existing nodes"*
- *"Identification of additional nodes"*
- *"Final node table and alias handling"*

The text should:

- *describe how the initial whiteboard node list was enriched with descriptions and evidence quotes,*
- *explain how additional, missed concepts were identified from the cleaned transcripts (including batching and guardrails such as "no invention"),*
- *summarize how merges or label adjustments were made and recorded (including use of an alias glossary), and*
- *note that the final nodes_step1_complete.csv contains all accepted nodes with stable IDs, descriptions, evidence, and coding needed for Step 2.*

User message - Part C: Link extraction and open issues

Task: Draft the "Link extraction and open issues" section of the Step 1 Report, including a short concluding paragraph for Step 1.

Inputs:

- *Final link table: links_step1_complete.csv*
  - *includes enriched whiteboard links and accepted additional links*
- *Intermediate link tables (if available), e.g. links_whiteboard_enriched.csv, links_new_candidates.csv*
- *Any link-level decision logs (e.g. link_decision_log.csv) and notes*
- *nodes_step1_complete.csv (for context)*

Output:
A minimally 400-600 word draft that:

- *explains how existing workshop links were enriched with evocative names, descriptions, and evidence,*
- *describes how additional causal relations were proposed and screened (including guardrails about explicit causality and non-invention),*
- *emphasizes that all accepted links are evidence-anchored (quotes + timestamps) and use stable IDs,*
- *lists any issues flagged for Step 2 (e.g. ambiguous links, potential duplicates, unclear boundaries), and*
- *closes with a short summary of the Step 1 outputs:*
  - *cleaned transcript files,*
  - *nodes_step1_complete.csv,*
  - *links_step1_complete.csv, and*
  - *any decision logs and alias glossaries.*

The concluding paragraph should state explicitly that these artefacts, together with the Step 1 Report, form the only input used to initiate Step 2 under the clean-slate re-entry principle.

For automatic report generation, we recommend to attach this appendix (or at least the relevant subsection A.1) as an additional input to each user message, so that the AI obtains direct access to the applied methodology.

A.2 Step 2: Harmonization and merging support

Step 2 combines the workshop-level maps into a single, ID-stable combined map while preserving provenance and stakeholder fidelity. It uses the Step 1 node and link tables for each workshop, together with their Step 1 reports, to:

- identify candidate cross-workshop merges,
- screen for cross-workshop relations,
- perform consistency checks, and
- document the process in a Step 2 Report.

No new structure is introduced in this step: the combined map is formed exclusively from nodes and links that are already evidenced in the workshop materials.

As with Step 1, all work is done in small, supervised batches with clean-slate re-entry between major subtasks when needed.

Cross-workshop node harmonization

This sub-step proposes candidate merges between nodes from different workshops. The model surfaces possibilities, humans decide.

System message

You are a data reconciliation assistant for cross-workshop harmonization. Your task is to propose candidate merges between node lists from different workshops.

Guardrails:

- *You must not delete, rename, or merge any nodes yourself.*
- *You only propose candidate groups of nodes that might refer to the same concept within and across workshops.*
- *Use the information in the attached Step 1 node tables and, where needed, the Step 1 reports for context (definitions, examples, indicators).*
- *Apply the three merging categories:*
    - *same concept (near-identical wording and scope),*
    - *strong overlap (substantial shared mechanism, minor wording differences),*
    - *related but distinct (connected but analytically separable concepts).*
- *When unsure, prefer "related but distinct" over "same concept" or " strong overlap".*
- *Base your suggestions on a qualitative "two-of-three" test (compare definitions, compare transcript anchors, compare indicator compatibility)*
- *Treat all outputs as suggestions for human review, not as decisions.*

Output format (CSV):
Return a CSV block with one header row and one row per candidate group:

- *headers: candidate_group_id, workshop1_node_ids, workshop1_node_labels, workshop2_node_ids, workshop2_node_labels, proposed_relation, rationale*
- *Multi-item fields use "item1 || item2".*
- *proposed_relation is one of "same concept", "strong overlap", or "related but distinct".*
- *rationale briefly cites definitions, usage, transcript anchors and potential indicators to justify the assessment.*

User message (per batch)

Task: Using the attached Step 1 node tables and reports for separate workshops, propose candidate cross-workshop node merges.

Inputs:

- *nodes_step1_W1_complete.csv*
- *nodes_step1_W2_complete.csv*
- *step1_report_W1.pdf (for context; optional)*
- *step1_report_W2.pdf (for context; optional)*

Output:
A CSV block with the header:

candidate_group_id, workshop1_node_ids, workshop1_node_labels, workshop2_node_ids, workshop2_node_labels, proposed_relation, rationale

Example row:

G01, "W1_N005", "Water Quality", "W2_N001", "Water Quality", "same concept", "Definitions and Step 1 reports show identical scope and usage in both workshops."

Instructions:

- *Work in small batches (e.g. focus on ecological nodes first, then governance, then market-related nodes).*
- *Be conservative and avoid over-merging: it is better to miss a potential merge than to suggest collapsing conceptually distinct items.*

Human reviewers must decide which candidates to merge, update the alias glossary, assign new combined node IDs, and remove superfluous links from an updated link table.

Cross-workshop relation screening

This sub-step looks for causal relations that are supported across workshops (or strongly in one and contextually in the other), classifying them into three tiers.

System message

You are a cautious systems mapper.
Your task is to propose potential cross-workshop causal relations between nodes, based on existing Step 1 link tables and the harmonized node set.

Guardrails:

- *You may not invent new nodes.*

- *You may only propose cross-workshop links between nodes that already exist in the workshops' node tables.*
- *New links must connect a node from one workshop to a node from another workshop.*
- *Each proposed link must be classified as:*
    - *Tier 1: explicit phrasing or consistent context in both workshops,*
    - *Tier 2: explicit phrasing or consistent context in at least one workshop,*
    - *Tier 3: weak evidence.*
- *Treat all proposals as hypotheses for human review.*

Output format (CSV):

- *proposed_cross_link_id, source_node_id, target_node_id, tier, workshop1_evidence_quotes, workshop1_timestamps, workshop2_evidence_quotes, workshop2_timestamps, rationale, notes*
- *Evidence fields may contain multiple items separated by " || ".*
- *Use notes to flag any ambiguity or reasons for assigning Tier 3.*

User message (per batch)

Task: Using the final node and link tables for each workshop, identify potential cross-workshop causal relations.

Inputs (for all workshops X):

- *nodes_step1_WX_complete.csv (Workshop X nodes with evidence)*
- *links_step1_WX_complete.csv (Workshop X links with evidence)*
- *step1_report_WX.pdf (optional context)*

Output:

- *A CSV with header:*
    - *proposed_cross_link_id, source_node_id, target_node_id, tier, workshop1_evidence_quotes, workshop1_timestamps, workshop2_evidence_quotes, workshop2_timestamps, rationale, notes*
- *Example rows:*
    - *X_001, W1_N001, W2_N031, "Tier 1", "W1 quote 1 || W1 quote 2", "00:14:10 || 00:19:05", "W2 quote 1", "00:22:30", "Both workshops state that marine protected areas improve shared marine space management.", ""*
    - *X_002, C18, C27, "Tier 2", "W1 explicit quote", "00:33:12", " W2 quote supporting the implied continuation", "00:15:41", "Explicit relation in W1; W2 provides anecdotal discussion but no direct phrasing.", "Tier 2; log if not included."*

Instructions:

- *Propose Tier 1 and Tier 2 links only when evidence is strong and direction is clear.*
- *Use Tier 3 only for weak or suggestive relationships that should not be added to the combined map at this stage but may be useful in the decision log.*

Only Tier 1 and Tier 2 candidates are considered for inclusion in the combined map; Tier 3 items are logged but not added. Human reviewers will manually decide which Tier 1 and Tier 2 links to include and record all decisions in the Step 2 decision log.

Consistency checks and alias glossary consolidation (optional helper)

After node and link harmonization, a short consistency pass helps ensure that the combined map is structurally sound and that alias information is complete.

System message

You are a consistency checker and documentation assistant.
Your task is to scan the harmonized node and link tables for structural and naming issues and to help consolidate alias information for the combined map.

Guardrails:

- *You must not alter nodes or links directly.*
- *You only flag issues and suggest potential alias entries for human review.*
- *Issues to look for include:*
  - *duplicate or confusingly similar labels in the combined node table,*
  - *links whose source or target IDs do not exist in the node table,*
  - *exact duplicate links (same source and same target),*
  - *isolated nodes (no in- or outgoing links).*

Output formats:

1. *Issues table (CSV):*

   issue_id, issue_type, affected_ids, description, suggested_action

2. *Alias suggestions (CSV, optional):*

   alias_group_id, preferred_label, alias_labels, combined_node_ids, rationale

User message

Task: Check the harmonized combined map for structural issues and propose alias entries when helpful.

Inputs:

- *nodes_step2_harmonized.csv; final combined node table*
- *links_step2_harmonized.csv; combined link table after cross-workshop decisions*
- *Existing alias glossary (if any): alias_glossary_step1.csv*

Output:

1. *An issues CSV:*
    - *issue_id, issue_type, affected_ids, description, suggested_action*
    - *I01, "dangling_link", "L045", "Link references missing target node C99.", "Check if C99 should be added or link removed."*
    - *I02, "duplicate_label", "N012, N034", "Two nodes share very similar labels for different concepts.", "Clarify wording or add aliases to distinguish.*
2. *An alias suggestions CSV (optional):*
    - *alias_group_id, preferred_label, alias_labels, combined_node_ids, rationale*
    - *A01, "Pollution (Chemical & Litter)", "Pollution; Chemical Pollution; Litter", "N002", "Merge workshop-specific labels under one preferred label while keeping originals as aliases."*

Instructions:

- *Focus on surfacing issues and candidate alias groups; we will review and decide on all changes manually.*
- *If there are no significant issues or alias opportunities, output only the header rows.*

Step 2 Report: documentation of harmonization outputs

As with Step 1, the process and results of Step 2 should be captured in a Step 2 Report, which becomes the canonical input to Step 3 under the clean-slate re-entry principle.

The report can be drafted with AI assistance, but should be built sub-step wise, using separate prompts for node harmonization, cross-workshop relations, and consistency checks. When using AI assistance, we recommend to attach this appendix as additional source for applied methodology.

System message

You are a technical report writer.
Your task is to draft parts of the Step 2 Report that documents how workshop maps were harmonized into a single combined map.

Guardrails:

- *You must base your text only on the attached CSV files and logs (no invention of nodes, links, or decisions).*
- *Summaries should describe what was actually done: criteria, procedures, and outcomes.*
- *Use concise academic language with clear subheadings.*
- *Treat each output as a draft for human editing, not as final prose.*

User message - Part A: Node harmonization summary

Task: Draft the node harmonization section of the Step 2 Report.

Inputs:

- *nodes_step1_WX_complete.csv (nodes from each workshop)*
- *nodes_step2_harmonized.csv*
- *node_merge_candidates_step2.csv (output from cross-workshop node harmonization)*
- *alias_glossary_step2.csv (if compiled)*
- *notes about the process*

Output a minimally 400-600 word draft section with subheadings such as:

- *"Initial node sets"*
- *"Merging criteria and procedure"*
- *"Cross-workshop node decisions"*
- *"Alias glossary updates"*

The text should:

- *describe how the workshop node sets were compared,*
- *explain the categories same concept, strong overlap, related but distinct,*
- *summarize the main types of merges (with a few representative examples), and*
- *note how alias information is preserved.*

User message - Part B: Cross-workshop relation summary

Task: Draft the cross-workshop relation screening section of the Step 2 Report.

Inputs:

- *links_step1_WX_complete.csv (links from each workshop)*
- *cross_workshop_relations_step2.csv (Tier 1, Tier 2, Tier 3 proposals)*
- *links_step2_combined.csv (final combined link table)*
- *notes about the process*

Output a minimally 300-500 word draft section that:

- *explains the Tier 1 / Tier 2 / Tier 3 classification,*
- *summarizes how many relations fall into each tier,*
- *describes which kinds of relations were ultimately added to the combined map, and*
- *notes how weaker Tier 3 proposals were logged but not included.*

User message - Part C: Consistency checks and outputs

Task: Draft the consistency checks and outputs section of the Step 2 Report and provide a short closing summary.

Inputs:

- *nodes_step2_harmonized.csv*
- *links_step2_combined.csv*
- *issues_step2_consistency.csv (if produced)*
- *alias_glossary_step2.csv*

Output a minimally 300-500 word draft that:

- *summarizes the consistency checks performed (duplicates, dangling links, etc.),*
- *lists the final outputs of Step 2 (combined node and link tables, alias glossary, decision log), and*
- *explicitly states that these artefacts form the clean-slate input for Step 3.*

This closes Step 2 and prepares the ground for the feedback-structure analysis of Step 3.

A.3 Step 3: Cycle identification, focal points, and virtuous mechanisms

Step 3 reorganizes the evidence-anchored combined map from Step 2 into:

1. A restricted set of vicious-cycle systems,
2. Focal points where multiple vicious cycles converge, and
3. Virtuous mechanisms that stakeholders associate with improvement at those focal points.

The analysis operates only on the harmonized node and link tables plus their evidence and DAPSI(W)R(M) coding, and does not introduce any new nodes or links. All cycles must remain auditable back to stakeholder quotations.

Node categorization and operationalization of DAPSI(W)R(M) are provided in the harmonized node table and in accompanying coding files (e.g. DAPSIR_definitions.txt). In addition, each chain and loop are assigned to one or more high-level system categories: social, political, ecological, cultural, institutional, and economic system (SPECIES).

Step 3 proceeds iteratively in three passes:

1. Identify stakeholder-supported vicious cycles, grouped into dominant SPECIES-tagged systems.
2. Derive focal points from those vicious systems.
3. Identify stakeholder-anchored virtuous cycles that specifically act on the focal points, grouped into dominant SPECIES-tagged systems.

All outputs are generated in small batches, with human review after each run, and the Step 3 Report is compiled at the end as a clean-slate artefact for Step 4.

Vicious cycle identification (stakeholder-supported)

This sub-step identifies vicious-cycle systems supported by stakeholder discussion. It uses both the topology of the harmonized map and the link-level evidence (quotes and timestamps), with optional access to the cleaned transcripts.

The extraction is deliberately multi-step:

1. First, identify the most dominant vicious-cycle system that may contain one or more loops and/or chains and that matches one or more SPECIES category (Social, Political, Ecological, Cultural, Institutional, and/or Economic System).
2. Query which nodes remain orphaned (not yet included in any previously identified vicious cycle) and check whether any stakeholder-supported cycles can be formed that incorporate them non-exclusively following the same criteria as for the previous item.
3. Repeat previous step until all SPECIES categories are sufficiently represented, no orphaned nodes remain, or no more stakeholder supported vicious cycles can be identified.

System message

You are a graph-theory analyst and systems thinker.
Your task is to identify stakeholder-supported vicious loops and chains in the combined map and group them into dominant cycle systems.

Guardrails:

- *You may only use nodes and links from the harmonized map (nodes_step2_harmonized.csv, links_step2_harmonized.csv).*
- *You must not invent new links or nodes.*
- *A loop or chain is valid only if it:*
    - *(only loop) starts and ends at the same node,*
    - *follows existing link directions for every edge, and*
    - *is supported by stakeholder evidence (via link-level quotes and timestamps, and where needed, transcript lines).*
- *Prefer loops and chains that:*
    - *are structurally coherent,*
    - *align with DAPSI(W)R(M) flows (e.g. Driver/Activity → Pressure → State → Impact/Welfare → Response → Pressure), and*
    - *are salient in stakeholder discourse (multiple links with strong evidence).*
    - *Use* `DAPSIR_definitions.txt` *and* `Operationalize_Map.txt` *for instructions on how to operationalize.*
- *Group loops and chains into vicious cycles (self-reinforcing degradation or problem dynamics) that:*
    - *represent one or two SPECIES categories (social, political, ecological, cultural, institutional, and economic systems),*
    - *represent problem dynamics discussed by stakeholders, and*
    - *represent a logical group with overlapping nodes and links.*
- *Work in multiple passes:*
    1. *Find most dominant vicious loops and chains for one or two SPECIES categories and group,*
    2. *Search for dominant vicious cycles that specifically but not exclusively include nodes not yet covered in terms of one or two SPECIES categories,*
    3. *Continue with (2) until all SPECIE categories are covered, all nodes are covered, or no meaningful cycle can be found.*
- *Treat all outputs as candidates for human review.*

Output format (CSV):
For each pass, return a CSV block of identified loops and chains with header:

- *cycle_id, loop/chain_id, cycle_system_label, loop/chain_label, SPECIES_categories, DAPSIR_components, ordered_node_ids, ordered_link_ids, list_of_evidence_quotes, list_of_timestamps, narrative, confidence, notes*
- *cycle_id: a unique ID (e.g. CY001, CY002, ...).*
- *loop/chain_id: a unique ID (e.g. LC001, LC002, ...).*
- *cycle_system_label: short evocative name (e.g. "Pollution-Ecology-Livelihood spiral").*
- *loop/chain_label: short evocative name (e.g. "Socio-Cultural Shifts").*
- *SPECIES_categories: list of relevant SPECIES tags (e.g. "ecological || economic || social").*
- *DAPSIR_components: list of DAPSI(W)R(M) categories traversed in the loop or chain (e.g. "Pressure || State || Impact || Response").*

- *ordered_node_ids: comma-separated list of combined_node_ids in loop or chain order (in case of a loop, repeat the first as last item).*
- *ordered_link_ids: comma-separated list of link_ids matching the path of the loop or chain.*
- *list_of_evidence_quotes: one or more verbatim quotes for logic in the loop/chain, joined with " || ".*
- *list_of_timestamps: corresponding timestamps, joined with " || ".*
- *narrative: Narrative of the course and logic of the chain or loop.*
- *confidence: "High", "Medium", "Low" for the chain or loop as a whole.*
- *notes: brief comments (e.g. ambiguity, borderline nodes).*

User message - First Pass: Dominant vicious system by SPECIES domains

Task (First Pass): Identify the most dominant vicious-cycle system in the combined map, focusing on a cycle where stakeholder evidence is strongest, and aligned to one or two SPECIES categories.

Inputs:

- *nodes_step2_harmonized.csv*
- *links_step2_harmonized.csv*
- *step2_report.pdf; for context on merging decisions (optional)*
- *Cleaned workshop transcripts (optional, for additional verification):*
    - *transcript_cleaned_WX.txt (add for each workshop X)*

Output:
A CSV table with header:

- *cycle_id, loop/chain_id, cycle_system_label, loop/chain_label, SPECIES_categories, DAPSIR_components, ordered_node_ids, ordered_link_ids, list_of_evidence_quotes, list_of_timestamps, narrative, confidence, notes*

Instructions:

- *Focus on vicious cycles that represent self-reinforcing degradation, in line with stakeholder descriptions.*
- *Aim to surface the most dominant cycle system that mostly matches one or two SPECIES domains (social, political, ecological, cultural, institutional, economic system).*
- *Prefer long loops and chains with strong evidential support across several links; do not include weakly supported loops/chains but short ones may be included.*

Humans must review the output list, adjust system labels, and refine membership by hand.

User message - Subsequent Passes: Additional vicious systems (iteratively)

Task (Subsequent Pass): Identify an additional vicious cycle that forms a second tier of problem systems not captured in earlier Passes.

Inputs:

- *Same as First Pass, plus:*
- *cycles_step3_vicious_pass1.csv; output of First Pass*
- *[optional] cycles_step3_vicious_passX.csv; output of earlier Subsequent Passes (Pass X).*

Output:
Same CSV structure as First Pass.

Instructions:

- *First, list nodes that do not appear in any of the previous cycle(s) from the First Pass and previously executed Subsequent Passes.*
- *Then, for a subset of these "orphaned" nodes, search for stakeholder-supported loops and chains that include them, subject to the same guardrails.*
- *Only include chains and loops that are substantively meaningful in the context of the map (not trivial or artefactual).*
- *Exclude chains and loops that are clearly covered by the dominant systems from earlier Passes (or differ only trivially).*
- *Prioritize loops and chains that:*
    - *extend dominant systems into new nodes or SPECIES categories, or*
    - *reveal substantively different problem mechanisms.*
- *Again, keep only chains and loops with clear stakeholder support.*

Humans must review and decide whether to keep or drop these additional cycles.

After each of these passes, researchers consolidate the vicious cycles, ensure there is no duplication, and assign final system-level group labels where appropriate (e.g. "Pollution-ecological-livelihood spiral", "Governance erosion system", "Market and economic-pressure system").

Focal point identification (from vicious cycles)

Focal points are nodes where multiple vicious cycles concentrate and are, explicitly or implicitly, perceived by stakeholders as bottlenecks or leverage points.

System message

You are a cautious systems analyst.
Your task is to identify candidate focal points based on the vicious cycles identified earlier.

Guardrails:

- *You may only work with accepted vicious cycles and the current harmonized node table.*
- *You may not change the graph structure or invent new nodes.*
- *Consider both structural and substantive criteria:*
    - *structural recurrence (node appears in several vicious cycles),*
    - *cross-category reach (connects multiple DAPSI(W)R(M) and SPECIES categories),*
    - *stakeholder salience (frequently discussed or emphasized in Step 1 evidence).*
- *Your output is advisory; humans make the final focal-point decisions.*

Output format (CSV):

focal_point_id, node_id, node_label, cycle_ids_involved, number_of_cycles, stakeholder_salience_notes, systemic_reach_notes, confidence, notes

User message

Task: Propose focal points based on the accepted vicious cycles and the combined node table.

Inputs:

- *cycles_step3_vicious_all.csv; consolidated vicious cycles from all Passes*
- *nodes_step2_harmonized.csv*
- *Optionally, Step 1 reports and node tables for additional context:*
    - *step1_report_WX.pdf (for each workshop X)*
    - *transcript_cleaned_WX.txt (for each workshop X)*

Output:

- *A CSV table with header:*
    - *focal_point_id, node_id, node_label, cycle_ids_involved, number_of_cycles, stakeholder_salience_notes, systemic_reach_notes, confidence, notes*
- *Example row:*
    - *FP01, C2, "Pollution (Chemical & Litter)", "CY001 || CY003 || CY007","3", Frequently mentioned as a central problem in all workshops.", "Connects pollution, water quality, stocks, and livelihoods across multiple DAPSI(W)R(M) categories.", "High", "Primary focal point in pollution-ecology-livelihood system."*

Instructions:

- *Focus on nodes that appear in several vicious cycles and clearly bridge different parts of the map.*
- *Provide short qualitative notes on stakeholder salience and systemic reach.*

Humans must review and confirm the list of focal points and may collapse or adjust some entries.

Virtuous mechanisms acting on focal points

This sub-step identifies virtuous cycles and improvement chains that act on previously identified focal points. Virtuous cycles must be:

- built solely from existing nodes and links,
- compatible with DAPSI(W)R(M) flows,
- demonstrably supported by stakeholder discussion (via link evidence and transcripts),
- specifically targeted at the focal points, and
- grouped into dominant SPECIES-tagged systems.

System message

You are a systems mapper focusing on improvement dynamics.
Your task is to identify virtuous cycles (loops and chains) that act on previously identified focal points, using only the existing combined map and stakeholder evidence.

Guardrails:

- *You may only use existing nodes and links; do not invent structure.*
- *Do not mechanically invert vicious cycles. Instead, look for stakeholder-described improvement mechanisms (e.g. pollution management, cooperative strengthening, adaptive governance).*
- *Every proposed virtuous loop or chain must:*
  - *include at least one focal point as a direct or indirect target,*
  - *be supported by existing link-level evidence (quotes, timestamps),*
  - *be consistent with DAPSI(W)R(M) coding, and*
  - *match one or two SPECIES domains (social, political, ecological, cultural, institutional, and economic system).*
- *Treat virtuous cycles as candidates; humans make final decisions.*

Output format (CSV):

virtuous_cycle_id, loop/chain_id, cycle_system_label, loop/chain_label, focal_points_affected, ordered_node_ids, ordered_link_ids, SPECIES_categories, DAPSIR_components, list_of_evidence_quotes, list_of_timestamps, narrative, confidence, notes

User message - First Pass: Virtuous cycle for primary focal points

Task (First Pass): Identify the most dominant virtuous cycle in the combined map that acts on the primary focal points identified earlier, focusing on loops and chains where stakeholder evidence is strongest, and aligned to one or two SPECIES categories.

Inputs:

- *nodes_step2_harmonized.csv*
- *links_step2_harmonized.csv*
- *focal_points_step3.csv; consolidated focal points*
- *cycles_step3_vicious_all.csv; for context*
- *Cleaned transcripts (optional):*
    - *transcript_cleaned_WX.txt (for each workshop X)*

Output:

- *A CSV with header:*
    - *virtuous_cycle_id, loop/chain_id, cycle_system_label, loop/chain_label, focal_points_affected, ordered_node_ids, ordered_link_ids, SPECIES_categories, DAPSIR_components, list_of_evidence_quotes, list_of_timestamps, narrative, confidence, notes*
- *Example row:*
    - *VC001, LC012, "Pollution management & ecological recovery", "Diversification Loops", "FP01 || FP02","N037 || N008 || N003 || N021 || N002 || N037", "L201 || L055 || L088 || L134 || L015", "social || institutional || ecological", "Response || Impact || Pressure","Quote1 || Quote2","00:51:10 || 00:54:22"," Local cooperatives and adaptive governance support pollution management that stabilizes livelihoods via improved water quality.", "High",""*

Instructions:

- *Prioritize virtuous mechanisms that:*
    - *intersect the main vicious systems,*
    - *are explicitly described by participants as improvement pathways,*
    - *operate across multiple DAPSI(W)R(M) categories,*
    - *and mostly align with one or two SPECIES categories.*
- *Keep narratives implicit in cycle_system_label and explicit in the narrative field.*

User message - Subsequent Pass: Additional virtuous systems and orphan focal points

Task (Subsequent Pass): Identify additional virtuous mechanisms that:

- *act on secondary or less central focal points,*
- *fill gaps where focal points are not yet connected to any virtuous mechanism, or*
- *are aligned with new SPECIES categories.*

Inputs:

- *Same as First Pass, plus:*
  - *virtuous_cycles_step3_pass1.csv; output of Pass 1*
  - *[optional] virtuous_cycles_step3_passX.csv; output of other earlier passes*

Output:

Same CSV structure as First Pass.

Instructions:

- *First, list nodes that do not appear in any of the previous virtuous cycle(s) from the First Pass and previously executed Subsequent Passes.*
- *Then, for a subset of these "orphaned" nodes, search for stakeholder-supported chains and loops that include them, subject to the same guardrails.*
- *Only include chains and loops that are substantively meaningful in the context of the map (not trivial or artefactual).*
- *Avoid duplicating mechanisms already captured in earlier passes; instead, extend or complement them.*
- *Look for stakeholder-described mechanisms involving, for example, monitoring, knowledge sharing, market improvements, or cooperative functions that stabilize the system.*
- *Prioritize chains and loops that:*
  - *extend dominant systems into new nodes or SPECIES categories, or*
  - *reveal substantively different problem mechanisms.*

Humans must review and decide how to group these into broader virtuous-cycle families.

Step 3 Report: documentation of cycle analysis

As with previous steps, all work in Step 3 should be documented in the Step 3 Report, which becomes the clean-slate starting point for Step 4 (scenario analysis).

The report describes:

- how vicious cycles were identified,
- how focal points were derived, and
- how virtuous mechanisms were constructed and grouped.

The report can be drafted with AI support in sub-step-wise prompts but in that case we recommend to attach this appendix as a source of the applied methodology.

System message

You are a technical report writer.
Your task is to draft sections of the Step 3 Report that document vicious cycles, focal points, and virtuous mechanisms.

Guardrails:

- *Base your text only on the attached CSV tables and previous step reports.*
- *Do not invent cycles, focal points, or mechanisms that are not present in the data.*
- *Use concise, academic language and clear subheadings.*
- *Treat all text as draft for human editing.*

User message - Part A: Vicious cycles and systems

Task: Draft the vicious cycles section of the Step 3 Report.

Inputs:

- *nodes_step2_harmonized.csv*
- *links_step2_harmonized.csv*
- *cycles_step3_vicious_passX.csv*
- *cycles_step3_vicious_all.csv*
- *step2_report.pdf*

Output:

- *A minimally 500-800 word draft with subheadings such as:*
  - *"Procedure for vicious-cycle identification"*
  - *"Dominant vicious-cycle systems by SPECIES domains and DAPSI(W)R(M) logic"*
  - *"Coverage and remaining blind spots"*
- *The text should:*
  - *describe the three-pass procedure (dominant systems, secondary systems, orphan coverage),*
  - *explain how DAPSI(W)R(M) coding and SPECIE categorizing informed cycle selection, and*
  - *provide representative examples.*

User message - Part B: Focal points

Task: Draft the focal points section of the Step 3 Report.

Inputs:

- *focal_points_step3.csv*

- *cycles_step3_vicious_all.csv*
- *nodes_step2_harmonized.csv*

Output:

- *A minimally 300-500 word draft that:*
  - *explains the focal-point criteria (recurrence, systemic reach, stakeholder salience),*
  - *summarizes the main focal points and their roles in the vicious-cycle systems, and*
  - *notes how they map onto DAPSI(W)R(M) and SPECIES categories.*

User message - Part C: Virtuous mechanisms and conclusion

Task: Draft the virtuous mechanisms section and a short conclusion for the Step 3 Report.

Inputs:

- *virtuous_cycles_step3_passX.csv (one for each pass)*
- *virtuous_cycles_step3_all.csv*
- *focal_points_step3.csv*
- *cycles_step3_vicious_all.csv*
- *nodes_step2_harmonized.csv*
- *links_step2_harmonized.csv*

Output:

- *A minimally 400-600 word draft that:*
  - *describes how virtuous cycles and improvement chains were identified,*
  - *explains their relationship to focal points and vicious systems,*
  - *outlines any virtuous-cycle families (e.g. "pollution management & ecological recovery", "adaptive & inclusive governance", "cooperatives & livelihood strengthening"), and*
  - *closes with a brief reflection on how the Step 3 artefacts (cycle tables, focal points, virtuous mechanisms) feed into Step 4 scenario design.*

The completed Step 3 Report, together with the cycle, focal-point, and virtuous-cycle CSVs, constitutes the only Step 3 input used to initiate Step 4 under clean-slate re-entry.

A.4 Step 4: Scenario specification and narration

Step 4 uses the validated combined map and the feedback structures from Step 3 to construct qualitative scenarios that trace stakeholder-style "what if" questions through the existing system.

Scenarios are:

- Hypotheses, not forecasts
- Strictly constrained to the existing nodes, links, vicious/virtuous cycles, and focal points
- Documented in structured scenario specification tables and accompanying narratives

The workflow for Step 4 has two main technical sub-steps:

1. Scenario specification from stakeholder-style questions
2. Constrained scenario narration

All work proceeds in small batches with human review between runs, and a Step 4 Report documents the process as the clean-slate handover to any downstream use.

Scenario specification from stakeholder-style questions

This sub-step turns stakeholder-style "what if" questions into structured scenario entries that reference:

- entry nodes,
- focal points,
- engaged vicious and virtuous cycles,
- mechanism paths through the map,
- time-structured effects,
- guardrails and risks, and
- indicative indicators (and optionally falsifiable outcomes).

System message

You are a policy scenario analyst.
Your task is to convert stakeholder-style "what if" questions into structured scenario specifications that refer only to the existing conceptual map and Step 3 outputs.

Guardrails:

- *You may not create new nodes, links, or cycles.*
- *You may only reference:*
  - *nodes and links in the combined map,*
  - *vicious and virtuous cycles identified in Step 3,*
  - *focal points confirmed in Step 3.*
- *Treat scenarios as hypotheses, not forecasts.*
- *Every causal statement in a scenario must correspond to an existing link; if not, it must be flagged as a limit of the map.*
- *Use DAPSI(W)R(M) roles as background to select plausible mechanism paths and time horizons, but do not alter the map.*

- *expect that humans will edit the results.*

Output format (CSV):
For each scenario, return a CSV block with header:

scenario_id, question, entry_node_ids, primary_focal_points, engaged_vicious_cycle_ids, engaged_virtuous_cycle_ids, mechanism_path_node_ids, short_term_effects, medium_term_effects, long_term_effects, risks_and_backfires, indicative_indicators, falsifiable_outcome, notes

Fields:

- *entry_node_ids, primary_focal_points, engaged_vicious_cycle_ids, engaged_virtuous_cycle_ids, mechanism_path_node_ids, indicative_indicators may each contain multiple items separated by " || ".*
- *short_term_effects, medium_term_effects, long_term_effects, risks_and_backfires are short textual summaries constrained by existing structure.*
- *falsifiable_outcome is optional and used only when a clear indicator + time window can be specified.*
- *notes can flag uncertainties or limits.*

User message (per scenario)

Task: For each of the attached stakeholder-style scenario questions, propose a comprehensive, detailed and structured scenario specification grounded in the existing map and Step 3 outputs.

Inputs:

- *Combined node table: nodes_step2_harmonized.csv*
- *Combined link table: links_step2_harmonized.csv*
- *Vicious-cycle table: cycles_step3_vicious_all.csv*
- *Virtuous-cycle table: virtuous_cycles_step3_all.csv*
- *Focal points: focal_points_step3.csv*
- *Optional: step2_report.pdf (for narrative context)*
- *Optional: step3_report.pdf (for narrative context)*
- *Scenario question (CSV):*
    - *with header:*
        - *scenario_id, question, optional_entry_node_hints*
    - *Example rows:*
        - *S01, "What would happen if we limit the number of ships in each port?", "N036 || N026"*
        - *S02, "What might happen if we advertise a new invasive species for consumption?", "N012 || N019"*

Output:

- *A CSV block with header:*
  scenario_id, question, entry_node_ids, primary_focal_points, engaged_vicious_cycle_ids, engaged_virtuous_cycle_ids, mechanism_path_node_ids, short_term_effects, medium_term_effects, long_term_effects, risks_and_backfires, indicative_indicators, falsifiable_outcome, notes
- *Example row:*
  S01, "What would happen if we limit the number of ships in each port?", "N036 || N026", "FP02 || FP01 || FP32", "CY001 || CY004", "VC001 || VC003", "N036 || N007 || N002 || N001 || N027 || N032", "Governance and space-use changes around vessel caps and enforcement.", "Changes in pollution loads, water quality, and ecological conditions near ports.", "Implications for fisher livelihoods, cooperative strength, and local markets.", "Displacement to uncapped coves; rebound tourism pressure; policy capture by tourism and port lobbies.", "Port-level vessel counts || Near-port water quality indicators || Reported conflict incidents || Income stability for small-scale fishers", "If caps are effective, near-port pollution and conflict indicators should improve over 3-5 years while small-scale income remains stable or increases.", "Entry nodes and mechanism path chosen to follow existing links through focal points Pollution, Water Quality, and Fisher Livelihood Security."

Instructions:

- *Ensure that all IDs in entry_node_ids, primary_focal_points, engaged_vicious_cycle_ids, engaged_virtuous_cycle_ids, and mechanism_path_node_ids exist in the attached Step 2 and Step 3 tables.*
- *If a plausible effect cannot be traced using existing links and cycles, do not add new structure; instead, mention the limitation in notes.*

Humans must review and manually adjust scenario specifications, including wording and indicator choices.

Constrained scenario narration

This sub-step transforms each structured scenario specification into a readable narrative that follows the existing mechanism path, distinguishes between short-, medium-, and long-term effects, and remains consistent with the map.

System message

You are a careful scenario narrator.
Your task is to convert a given scenario specification into a readable stakeholder-based narrative that closely mirrors the underlying node and link structure.

Guardrails:

- *You may not introduce new causal links, nodes, or cycles beyond those listed in the scenario specification.*
- *You must preserve:*
  - *the directionality of the mechanism path,*
  - *the short-/medium-/long-term structure of the effects, and*
  - *the distinction between vicious and virtuous dynamics.*
- *Use node labels and focal point names consistently (e.g. "Water Quality", "Fisher Livelihood Security").*
- *Clearly distinguish between:*
  - *implications directly supported by the map and Step 3 outputs, and*
  - *more speculative remarks, which should be minimized or explicitly hedged.*
- *Do not add new mechanisms, variables, or interventions.*
- *Use transcript quotes to argue the mechanism paths.*
- *Outputs are narrative text, not tables nor bullet point lists, and are subject to human editing.*

User message (per scenario)

Task: Using the scenario specification below, write a concise narrative (minimal 400-800 words) structured into:

1. *Motivation (with stakeholder emphasis) and scenario starting point*
2. *Expected pathways and outcomes (short-, medium-, and long-term)*
3. *Guardrails and implementation needs*
4. *Potential risks and backfires*
5. *Stakeholder perspective*
6. *Short synthesis ("bottom line")*

Inputs:

- *Scenario specification (single row from scenarios_step4_specifications.csv)*
- *Optional for reference:*
  - *nodes_step2_harmonized.csv,*
  - *links_step2_harmonized.csv,*
  - *cycles_step3_vicious_all.csv,*
  - *virtuous_cycles_step3_all.csv,*
  - *focal_points_step3.csv*
  - *transcript_cleaned_WX.txt (for each workshop X*

Instructions:

- *Use the six requested subheadings.*

- *Re-use the wording of node labels and focal points wherever this helps maintain alignment with the map.*
- *Do not introduce new causal relations, nodes, or cycles beyond those in mechanism_path_node_ids and the engaged cycles.*
- *Keep time structure clear:*
    - *Short-term = primarily governance, behavior, space use, and immediate pressures*
    - *Medium-term = state and impact changes (e.g. water quality, conflicts)*
    - *Long-term = livelihoods, institutional robustness, and systemic outcomes*

After generation, humans must check the narrative line by line against the scenario specification and correct any drift.

Step 4 Report: documentation of scenario analysis

As with previous steps, Step 4 should end with a Step 4 Report that documents:

- the scenario questions,
- the specification procedure,
- the resulting scenario set, and
- how the maps and cycles were used and constrained.

This report can be drafted with AI assistance, using sub-step-wise prompts but in that case we recommend to attach this appendix as a source for the applied methodology.

System message

You are a technical report writer.
Your task is to draft the Step 4 Report, documenting scenario specification and narration.

Guardrails:

- *Use only the attached scenario tables, cycle tables, and previous step reports.*
- *Do not invent scenario questions, mechanisms, or indicators.*
- *Use concise academic language with clear subheadings.*
- *Treat your output as draft text for human editing.*

User message - Part A: Scenario design and specification

Task: Draft the scenario design and specification section of the Step 4 Report.

Inputs:

- *scenarios_step4_specifications.csv*
- *focal_points_step3.csv*

- *cycles_step3_vicious_all.csv*
- *virtuous_cycles_step3_all.csv*
- *step3_report.pdf*
- *notes on the process*

Output:
A minimally 500-800 word draft section with suggested subheadings such as:

- *"Stakeholder-style questions and entry points"*
- *"Use of focal points and cycle families"*
- *"Scenario structure and guardrails"*

The text should:

- *explain how stakeholder-style questions were collected or synthesized,*
- *describe how entry nodes, focal points, and cycles were selected for each scenario,*
- *summarize the general scenario template (short-/medium-/long-term effects, risks, indicators, optional falsifiable outcomes).*

User message - Part B: Scenario narratives and indicators

Task: Draft the scenario narratives and indicators section of the Step 4 Report, plus a short conclusion for Step 4.

Inputs:

- *scenarios_step4_narratives.docx (final scenario narratives)*
- *scenarios_step4_specifications.csv*
- *Relevant indicator notes (if maintained separately)*
- *notes on the process*

Output:
A minimally 500-800 word draft that:

- *summarizes the scenarios and their main themes,*
- *describes how narratives were kept aligned with the map,*
- *outlines the indicative indicators and (optionally) any proposed falsifiable outcomes, and*
- *concludes with a short summary of how Step 4 operationalizes scenario analysis in the workflow and what its limitations are (qualitative, non-forecasting, etc.).*

Together, the Step 4 Report, the scenario specification CSV, and the narrative texts form the final artefacts of the pipeline and can be archived as the audit-ready output of the workflow.

Supplementary Material B: Scenario catalogue and specification details (for Step 4 case study example)

Step 4 applies the combined stakeholder map (and the vicious/virtuous systems derived in Step 3) to a set of qualitative "what-if" questions. In the Costa Brava case study, the scenario analysis was explicitly constrained to the project's conceptual maps and their underlying transcripts: no new links were added and no external datasets were introduced. The purpose is not forecasting, but assessing how far the existing feedback structure can carry realistic stakeholder-style questions, while foregrounding how virtuous cycles might be activated without re-triggering known vicious spirals.

B.1 Scenario set

The scenario set was produced by co-drafting ten stakeholder-style questions together with local collaborators, using workshop notes and transcript themes as a starting point. The questions were deliberately framed around repeatedly raised issues (for example, port congestion and space use; invasive species; or guild income), and are treated as structured entry points into the map rather than as researcher-defined hypotheses.

To maintain traceability between Steps 3 and 4, Table B1 summarizes the ten stakeholder-style scenarios used in the analysis, including their main leverage points in the map, the dominant positive and negative trajectories, and the key guardrails required to keep each scenario within a "virtuous corridor." The table documents, for each scenario, (i) the intervention being tested, (ii) its primary target point(s) within the map, (iii) the main positive and negative outcome branches observed during scenario tracing, and (iv) the guardrails needed to maintain a positive trajectory.

B.2 Scenario specification

Each scenario is documented as a stakeholder question with a consistent specification that preserves alignment with the map. The specification records: the entry node identifiers, the cycles and chains expected to be engaged, a mechanism path captured as identifiers only, effects by time horizon (short/medium/long), plausible risks or backfires (e.g., rebounds through adjacent loops), and indicators tied to specific nodes or links. Standard notes on scope, equal inputs across scenarios, human review, versioning, and researcher responsibility clarify that results should be read as decision-support rather than forecasts.

Where the exact question was not asked verbatim in the workshop, questions can be derived from recurring transcript themes and co-drafted with facilitators or local partners, to preserve stakeholder fidelity.

B.3 How scenarios were traced, and how "guardrails" were recorded

For each question, the combined conceptual map was queried by tracing first-, second-, and third-order pathways starting from the relevant themes, moving only along links already validated earlier and organized into feedback systems. In this process, "guardrails" were recorded as the

mechanisms that support desirable trajectories (often via virtuous cycles) and the mechanisms that risk reactivating undesirable dynamics (via vicious cycles).

B.4 Keeping narratives faithful to the map

The method does not prescribe interventions beyond what stakeholders articulated in the map: scenarios may reference measures or responses only when these already appear as nodes or relations in the combined map. A practical complement is the use of constrained narration prompts that produce stakeholder-readable descriptions mirroring the mechanism path, using explicit increase/decrease language and restating delays. These narratives can then be validated sentence-by-sentence by mapping statements back to identifiers, to reduce the risk of misrepresenting causal direction or polarity. For contested trade-offs, a second restatement pass (via a second agent or alternative prompt formulation) can help flag contradictions and strengthen internal consistency.

B.5 Optional “falsifiable outcomes”

As an optional extension, a scenario may include a falsifiable outcome in which a predicted effect is paired with one or more indicators and an indicative time window. The indicator is chosen so that it would reasonably move if the scenario mechanism is correct, turning the scenario into a testable claim that could later be corroborated or contradicted by measurement. In the present case study, falsifiable outcomes are treated as a conceptual extension (linking scenarios to plausible indicators), without testing thresholds against monitoring data, and recognizing that suitable indicators or timelines may not always exist.

Table B1: Overview of the ten stakeholder-style scenarios used in Step 4. This table summarizes the ten scenario questions used to explore the behavior of the combined conceptual map under different intervention logics. For each scenario, the table lists a short description of the intervention being tested, its primary target point(s) within the map, the main positive and negative outcome branches observed during scenario tracing, and the key guardrails required to maintain a positive trajectory. All scenarios are grounded in the node-link structure produced in Step 2 and act upon the focal points and reinforcing mechanisms identified in Step 3. The table demonstrates how scenario design remains traceable to stakeholder-derived feedback structures while allowing interventions to propagate freely across the conceptual map.

# / Scenario	Short description	Primary target point(s)	Primary outcomes (positive / negative branches)	Key guardrails for a positive trajectory
1. Port-level vessel caps: "What would be if we limit the number of ships in each port?"	Introduces a numerical, port-level cap on vessels as a governance-space-pollution lever to reduce crowding, conflicts and near-shore pollution, and to test whether this can flip the crowding spiral into a more regenerative regime.	**Pollution (Chemical & Litter)**; **Water Quality**; **Fisher Livelihood Security**	**Positive:** Decongests ports, reduces conflicts and enforcement burden, dampens pressure for new infrastructure, lowers pollution loads and sediment disturbance, improves water quality and biogeochemistry, and over time supports stock and livelihood recovery while strengthening cooperatives and fairer markets. **Negative:** If poorly designed, caps trigger displacement to uncapped coves, capacity substitution (fewer but larger/more intense craft), rebound "clear-water tourism" pressure, and policy capture or rollback by tourism and port lobbies.	Composite caps (vessels + passenger capacity + engine/emission class + noise/wake); basin-wide coordination across ports; coupling caps to pollution-management measures and ecological indicators (for revision); transparent permit allocation and co-management; and clear enforcement resources and parity across user groups.
2. "Eat the invader": "What might happen if we advertise a new (invasive) species for consumption?"	Tests a communication- and gastronomy-driven strategy that tries to convert invasive species into an income source and removal pressure, using local markets and CSF channels, while avoiding ecological or market backfires.	**Species & Ecosystem Change**; **Management of Invasive Species**; **Fisher Livelihood Security**; **Markets & Lobbies / Local Fair Markets**.	**Positive:** Targeted communication shifts consumption toward invasives, local gastronomy and CSF keep value in coastal communities, diversification enables knowledge-guided removals, and ecological pressure from invaders is reduced while livelihoods are buffered. **Negative:** If channels are captured by large buyers, the campaign strengthens concentrated markets and policy capture, increases waste and pollution from high-throughput consumption, risks mis-targeted removals that harm natives, and can provoke new space conflicts or problematic aquaculture responses.	Co-produced campaigns under adaptive governance; "knowledge-first" design (real-time observation and science guiding where/how invasives are targeted); explicit market architecture that privileges local gastronomy/CSF and cooperative bargaining; hard exclusion of invasive aquaculture; integration of low-waste norms and pollution-control measures; and spatial tools to manage crowding around removal hotspots.
3. Harbor mix: "Is there an equilibrium mix of recreation-fisheries-industry, and what if a port pivots to industry?"	Explores how reallocating harbor functions (fishing-forward, recreation-forward, industry/logistics) and an industrial pivot in a key port affect users, space conflicts, sediments, pollution, markets and small-scale fisheries.	**Infrastructure (Ports, Coastal & Energy)**; **Water Quality**; **Shared Marine Space Management**; **Fisher Livelihood Security**; **Markets & Lobbies**.	**Positive:** With strong rules, industrial upgrades can support safer berths, logistics and aquaculture–fishery integration, stabilize incomes, and create a governance learning loop that improves spatial planning and ecological buffers (e.g. MPAs). **Negative:** Unchecked industrialization intensifies sediment disruption and pollution, degrades water quality and habitats, lifts conflict and enforcement stress, shifts market/policy power towards large actors, accelerates small-scale exit, and may displace tourism and pressure other ports.	Anchor decisions in explicit space-use rules with zoning/rotations and parity enforcement; embed "water-quality-safe-by-design" standards and pollution management; pair industrial shifts with MPAs/restoration as ecological buffers; use real-time knowledge to tune siting and operations; and protect small-scale fleets through cooperative bargaining and fair-market rules so benefits do not bypass them.
4. Population doubling: "If	Tests whether higher resident/seasonal population	**Population Growth &**	**Positive:** If consumption is re-patterned, pollution is controlled at source, infrastructure is designed and operated to avoid	Demand-side redesign to flatten the consumption → pollution link

# / Scenario	Short description	Primary target point(s)	Primary outcomes (positive / negative branches)	Key guardrails for a positive trajectory
Costa Brava's population doubles, what keeps water quality acceptable and fisheries viable?"	can be made compatible with "appropriate" water quality and viable fisheries, focusing on consumption, infrastructure (incl. desalination), space conflicts, and governance capacity.	**Demand**; **Pollution**; **Water Quality**; **Infrastructure**; **Fisher Livelihood Security**.	marine degradation, and space/enforcement loops are kept strong, population growth can be decoupled from water-quality decline and allow fisheries to persist; desalination can contribute to freshwater security without harming coastal ecosystems. **Negative:** Without these guardrails, growth drives higher consumption, pollution and infrastructure pressure, erodes enforcement through crowding, amplifies market power and capture, and reproduces the canonical downward spiral from degraded water quality to stock and livelihood decline.	(communication, local channels, waste-light norms); "blue" infrastructure and desalination standards with adaptive pollution management; proactive space governance and parity enforcement; anticipation of market-power drift with cooperative counterweights; and a compact dashboard with thresholds that condition further expansion on ecological and conflict indicators.
5. Trawling ban: "What would happen if trawling is forbidden (area/season)?"	Evaluates a gear-specific regulatory measure that bans trawling in certain areas or seasons, and asks under which institutional, spatial and market conditions it delivers ecological recovery without destabilizing livelihoods.	**Stocks / Stock Decline**; **Ecological Resilience & Habitats (MPAs)**; **Fisher Livelihood Security**; **Shared Marine Space Management**.	**Positive:** When co-designed, fairly enforced and spatially planned, a trawl ban reduces seabed disturbance, supports habitat and water-quality recovery (often via MPA-like zones), benefits low-impact fleets and reputationally strengthens local fisheries, enabling better market positioning and eco-tourism options. **Negative:** If imposed top-down with weak enforcement, it can erode legitimacy, generate displacement conflicts, trigger market reconfiguration and capture, and provoke tourist/infrastructure rebounds that offset ecological gains.	Co-production under adaptive governance with strong, parity enforcement; explicit spatial design to manage displaced effort and cross-gear coexistence; coupling to MPAs/restoration where appropriate; concurrent market/communication package (chefs/CSF, demand steering) and transition support (training, gear switching); and monitoring with clear indicators and exit ramps for adaptive adjustment.
6. Capping recreational vessels per port: "What would happen if recreational vessels are restricted to a few numbers by port?"	Focuses specifically on leisure craft as a major driver of congestion, pollution and space conflicts, testing the effects of per-port recreational caps on governance, ecology and livelihoods.	**Tourism & Recreation Management**; **Shared Marine Space Management**; **Water Quality**; **Fisher Livelihood Security**.	**Positive:** Caps decongest ports and nearby waters, reduce conflicts and enforcement load, slow the push for new coastal infrastructure, lower pollution and sediment stress, and thereby improve water quality, ecological conditions and livelihood prospects, while breaking tourism driven feedback that otherwise amplifies pressure. **Negative:** If applied piecemeal, they can displace traffic to uncapped coves/ports, be perceived as unfair, squeeze professional fishing tourism (pescatourism) options, trigger rebound pressure when water looks "too good", or lock in a dirty vessel mix.	Regionally coordinated caps (not just local rules); transparent, co-designed allocation with communication and parity enforcement; reserved quota shares for professional diversification into tourism; composite permit criteria that favor low-emission/low-impact craft; coupling to MPAs/zoning and pollution-control measures; and real-time observation and dashboards to adjust caps and demonstrate benefits.
7. Temporary, species-specific ban: "What if there is a time-limited ban on a focal stock?"	Examines a monitored, time-bounded closure for a specific species as a proportionate response to acute stock stress, and whether it can protect the biological base without triggering social or market breakdown.	**Stocks / Stock Decline**; **Fisher Livelihood Security**; **Species & Ecosystem Change**; **Diversification**.	**Positive:** A well-designed species-specific ban arrests decline, supports stock rebuilding and future catch stability, and can, if bundled with diversification, communication and co-produced knowledge, stabilize incomes and strengthen cooperatives and local expertise. **Negative:** "Paper bans" with weak or uneven enforcement fuel non-compliance and conflict, displace effort onto other stocks and spaces, trigger market capture or price spikes, alienate	Co-designed, adaptive closure with science- and observation-based reopening thresholds; explicit space-use planning for displaced effort; an accompanying diversification and training package, including invasive targeting where appropriate; communication and gastronomy/CSF to steer demand; and

# / Scenario	Short description	Primary target point(s)	Primary outcomes (positive / negative branches)	Key guardrails for a positive trajectory
			small-scale fleets, and risk drifting into unmanaged tourism or prolonged closures without clear exit criteria.	enforcement and monitoring architecture that keeps parity and transparency high.
8. Cooperative viability threshold: "What income level keeps the cooperative functional?"	Interprets cooperative viability not as a single euro amount but as the income needed to sustain three core service loops: collective market leverage, knowledge-policy interface, and diversification/CSF/gastronomy innovation.	**Cooperatives**; **Markets & Lobbies / Fair Markets**; **Fisher Livelihood Security**; **Local / Traditional Expertise**.	**Positive:** Once recurring income reliably funds core market, knowledge and innovation functions, reinforcing loops take hold: better prices and channels raise livelihoods, guilds preserve and project knowledge into governance, diversification and niche markets expand demand for local products, and ecological upgrades via policy and technology become more feasible and beneficial. **Negative:** If income remains below this functional threshold, guilds hollow out, market power shifts outward, policy is more easily captured, tourism and infrastructure dynamics can run unchecked, and workforce decline accelerates, undermining small-scale viability.	Secure recurring revenue to power the three core loops; monitor operational proxies (first-sale performance, active CSF/gastronomy programs, knowledge-exchange frequency, membership trends) instead of chasing a single number; guard against policy capture; manage tourism and infrastructure spillovers; and invest systematically in communication/training and inclusive organization (including immigrant participation) to keep the guild a living institution.
9. Recreational fishing: expansion vs limitation: "What are the effects of recreational fishing on small-scale fisheries under expansion vs limitation?"	Compares uncontrolled growth versus deliberate limitation/capping of recreational fishing, focusing on space conflicts, governance, ecological impacts and professional small-scale fisheries.	**Shared Marine Space Management**; **Governance Effectiveness & Enforcement**; **Water Quality**; **Small-Scale Fishery Viability & Livelihoods**.	**Positive (with caps):** Rules-first coexistence (caps, zoning, parity enforcement) reduces conflicts, stabilizes enforcement and legitimacy, moderates infrastructure growth and pollution, and creates fair windows for professional fishing tourism (pescatourism) and tourism-linked markets without re-crowding grounds. **Negative (with uncontrolled expansion):** Rising recreational effort drives conflict and enforcement erosion, fuels infrastructure and pollution cascades that degrade water quality and stocks, shifts policy and market power towards tourism/leisure actors, and marginalizes small-scale fleets.	Integrated spatial rules and caps with parity enforcement; active communication, registries and real-time monitoring to shape behavior and shorten learning loops; targeted MPAs integrated into the same spatial regime; cooperative-led market design so tourism spending benefits professional landings (not grey markets); modernization linked to capacity-neutral outcomes; and periodic review of caps against population, ecological and conflict indicators.
10. Closed seasons (closure) vs. economic sustainability: "What is the delicate balance between closure and livelihoods?"	Assesses seasonal closures as a tool to relieve pressure on stressed stocks and habitats while maintaining economic viability, and asks when a closure becomes part of a virtuous regime rather than a social shock.	**Stocks / Stock Decline**; **Fisher Livelihood Security**; **Small-Scale Fishery Viability**; **Shared Marine Space Management**.	**Positive:** An adaptive, co-produced closure reduces fishing mortality, supports stock and habitat recovery, and, when paired with diversification, communication and fair enforcement, can stabilize livelihoods and strengthen cooperative and policy loops. **Negative:** Static, poorly enforced or top-down closures increase conflict and enforcement fatigue, displace effort and space conflicts, induce lasting market shifts to imports, fuel socio-cultural alienation and workforce exit, and may fail biologically if other pressures (pollution, climate) are not addressed.	Design closures through co-management with clear ecological and socio-economic indicators and exit ramps; maintain strong enforcement and transparent communication about timing, rationale and reopening criteria; pre-plan temporary spatial rules to manage displacement and integrate any MPA-style elements; support time-bounded diversification and training so households bridge income gaps; and use market/communication tools to keep value local and avoid long-term substitution away from local fleets.

Supplementary Material C: Workshop 2 node evolution

The Workshop 2 conceptual map underwent three structured transformations: (1) initial capture of whiteboard themes, (2) expansion through AI-supported transcript extraction, and (3) two rounds of compression to harmonize terminology and reduce redundancy while preserving stakeholder fidelity. The following subsections describe each transformation and its rationale.

Initial 40 nodes (Workshop 2 whiteboard map)

The workshop began with a whiteboard exercise in which participants identified and named 40 themes that reflected pressures, drivers, states, and system components relevant to the regional marine socio-ecological system. These themes served as the initial scaffolding for dialogue and later enabled the AI-supported extraction process to anchor new material in stakeholder language. Because the objective of Step 1 is to preserve stakeholder vocabulary before introducing any inference, all 40 labels were retained verbatim and assigned stable identifiers at first mention. These nodes formed the baseline against which transcript-derived additions were compared and later evaluated for merging.

Table C1: Initial nodes of Workshop 2.

ID	Theme name	ID	Theme name
1	Water Quality	21	Climate Change
2	Human Consumption (Patterns)	22	Species Diversification & Adaptation
3	Regulation (& Policy Framework)	23	Sustainable Vessel Transition
4	Temperature (Sea Temperature Rise)	24	Fair Market Price
5	Users (Marine Stakeholders)	25	Recreational Fishing Pressure
6	Pollution (Chemical & Litter)	26	Local Seafood & Gastronomy
7	Infrastructure (Ports, Energy, Logistics)	27	Decline in Fishers (Workforce)
8	Knowledge (Scientific & Technical)	28	Pollution Management & Reduction
9	Reduced Catch / Stock Decline	29	Water Treatment & Desalination
10	IUU Fishing	30	Communication & Stakeholder Dialogue
11	Population Growth & Demand Pressure	31	Multi-Role Fishers (Tourism & Science)
12	Species & Ecosystem Changes	32	Management of Invasive Species
13	Organizations & Governance Issues	33	Observational Monitoring
14	Enforcement Strictness	34	Management of Shared Marine Spaces
15	Restricted MPA Zones	35	Marine Infrastructure & Development
16	Gear Regulation	36	Real-Time Fisheries Monitoring
17	Vessel Regulation	37	Investment in Local Marine Science
18	Diversifying Fishing Grounds	38	Aquaculture & Fisheries Integration
19	Fisher Education and Training	39	Microplastic & Marine Litter Pollution
20	Immigrant Participation	40	Socio-Cultural Change

Expansion from 40 to 52 nodes

The first expansion occurred when the cleaned and segmented transcript was analyzed for concepts that had been discussed but were not represented on the whiteboard. Following the methodology for Step 1, the AI was asked to propose additional nodes only when the transcript provided explicit conceptual content not captured in the initial list. Each candidate was reviewed by analysts to ensure it reflected a stakeholder-introduced concept rather than an AI inference. Twelve new themes met this criterion and were incorporated as nodes 41-52. Their addition increased the breadth of the map but introduced no structural inference: the expansion phase remains purely evidential, anchored in stakeholder phrasing and supported by verbatim quotes and timestamps. These 52 nodes constituted the full pre-compression conceptual vocabulary for Workshop 2. New nodes introduced by the AI transcript analysis:

First compression (52 to 41): formation of new nodes

The first compression was performed within Workshop 2 during Step 1, using the controlled merging principles described in Section 2.5 to harmonize labels and consolidate redundant or closely overlapping themes. The decision rules emphasized preserving analytic resolution, retaining stakeholder language, and documenting every merge with a "source-to-target" lineage.

In this stage, seven new themes emerged as the result of merging conceptually overlapping nodes from the expanded 52-node set. These mergers occurred where the transcript anchors, definitions, and stakeholder usage indicated substantial conceptual equivalence or nested meaning. This produced a reduction to 41 nodes while preserving all evidence through stable identifiers and source traceability.

One theme, Ecosystem-Based Fisheries Management (old Theme 50), was not merged but removed: it was judged to be too broad in scope, functioning as an umbrella label that spanned governance, monitoring, ecological state, and fishery behavior without adding unique analytical resolution. Its component ideas remained represented through the more specific nodes to which stakeholders had attached direct causal statements.

Table C2: Workshop 2 nodes expansion by AI transcript analysis.

New ID	Theme name	New ID	Theme name
41	Fisher Livelihood Security	47	Diversified Economic Opportunities
42	Sustainable Market & Distribution Channels	48	Fisher-Inclusive Governance
43	Effective Enforcement & Surveillance	49	Fisher-Focused Infrastructure Support
44	Fishing Community Outreach & Image	50	Ecosystem-Based Fisheries Management
45	Tourism & Recreation Management	51	Community-Supported Local Fisheries
46	Local Fishing Cooperatives	52	Local Fisher Expertise & Traditional Knowledge

Second compression (41 to 34): formation of new nodes

The second compression applied the same controlled merging principles but with a narrower focus. Seven themes were consolidated at this stage. Each represents a thematic space where two or more original nodes addressed the same mechanism or described different aspects of a single stakeholder-identified process. These merges brought together temperature-related stressors, pollution pathways, infrastructure dependencies, monitoring functions, enforcement, and diversification dynamics. Importantly, the lineage remains traceable to the original 52-node set, providing full transparency for audit and interpretability.

The resulting 34-node map formed the basis for step 2 (conceptual map combination).

Supplementary Material D: Conceptual Maps with Vicious and Virtuous Cycles

This appendix presents the full combined conceptual map with all nodes and most links produced in Step 2, annotated with the vicious and virtuous cycles identified in Step 3. While Figure 3 in the main text provides a simplified, illustrative example of one vicious and one virtuous system, the figures in this appendix display the complete family of cycles identified in Step 3. They serve to demonstrate the transparency, reproducibility, and structural grounding of the cycle-identification procedure.

Table D1: First compression of Workshop 2 nodes.

New Theme Name	Source Theme Indices (52 node map)	Source Theme Names
Regulation (& Policy Framework)	3, 15, 16, 17	Regulation (& Policy Framework); Marine Protected Areas (MPAs); Fishing Gear Regulation; Vessel Regulation
Users (Marine Stakeholders)	5, 10, 25	IUU Fishing; Recreational Fishing Pressure
Infrastructure (Ports, Energy, Logistics)	7, 29	Infrastructure (Ports, Energy, Logistics); Water Treatment and Desalination
Knowledge (Scientific and Technical)	8, 37	Knowledge (Scientific and Technical); Investment in Local Marine Science
Sustainable Market and Distribution Channels	42, 49	Sustainable Market and Distribution Channels; Fisher Focused Infrastructure Support
Diversification (gears, grounds and side jobs)	18, 47	Diversifying Fishing Grounds; Diversified Economic Opportunities
Fisher Inclusive Governance Bodies (Guilds and Committees)	13, 48	Organizations and Governance Issues; Fisher Inclusive Governance Bodies (Guilds and Committees)
[Deleted]	50	Ecosystem Based Fisheries Management

Vicious-cycle families (Figure D1)

Figure D1 highlights all eleven vicious loops and chains identified from the combined map. Each highlighted link corresponds to a link in the Step 2 map and is supported by at least one stakeholder quotation, as described in Section 3. These cycles are grouped into the three vicious-cycle systems:

1. **Socio-Ecological Systemic Downward Spiral.** This system includes chains in which Pollution (Chemical & Litter) degrades Water Quality, intensifies Eutrophication, reduces Primary Production, and ultimately contributes to Reduced Catch / Stock Decline and declining Fisher Livelihood Security. These mechanisms also include loops in which ecological deterioration reinforces socio-economic stress, leading to responses that increase pressures (e.g., diversification into tourism or intensified spatial competition).
2. **Governance Disconnection and Institutional Erosion Cycle.** These loops capture how weaknesses in Regulation & Policy Framework, Governance Effectiveness & Enforcement, and stakeholder trust can reinforce one another, contributing to lower compliance, greater contestation of shared marine spaces, and reduced legitimacy of management actions. This is identified as a distinct family because the reinforcing structure operates primarily through governance rather than ecological variables.
3. **Ecological Change–Socio-cultural Adaptation–Tourism Transformation Spiral.** This family links climate-driven temperature change and extreme events with species and ecosystem changes, fisher responses involving diversification into tourism, and socio-cultural shifts. Its component pathways interact with tourism and recreation management, infrastructure, shared marine space, and pollution, as shown in Figure D1.

In Figure D1, links belonging to these families are color-coded, with non-cycle links omitted. The diagram demonstrates how the vicious cycles draw upon different regions of the combined map while converging on a shared set of focal points.

Table D2: Second compression of Workshop 2 nodes.

Final theme name	Source theme indices (52-node map)	Source theme names
Temperature (Climate Change)	4, 21	Temperature (Sea Temperature Rise); Climate Change
Pollution (Chemical, Microplastics & Litter)	6, 39	Pollution (Chemical & Litter); Microplastic & Marine Litter Pollution
Infrastructure (Ports, Energy, Logistics & Development)	7, 35	Infrastructure (Ports, Energy, Logistics); Marine Infrastructure & Development
Species & Ecosystem Changes	12, 22	Species & Ecosystem Changes; Species Diversification & Adaptation
Real-Time Fisheries Observation and Monitoring	33, 36	Observational Monitoring; Real-Time Fisheries Monitoring
Strict and Effective Enforcement & Surveillance	14, 43	Enforcement Strictness; Effective Enforcement & Surveillance
Diversification (gears, species, grounds & side jobs)	18, 31	Diversifying Fishing Grounds; Multi-Role Fishers (Tourism & Science)

Virtuous-cycle families (Figure D2)

Figure D2 overlays the twelve virtuous loops and chains identified in Step 3 onto the same combined conceptual map. These virtuous cycles were identified through the same constraints as the vicious ones, but with the additional requirement that they act on the focal points identified in Section 3.3.

The improvement pathways are grouped into five virtuous-cycle systems:

1. **Inclusive and Adaptive Governance for Sustainability.** This family links Adaptive & Inclusive Governance with regulation, enforcement, and shared marine space management. It includes feedbacks through marine users and related pathways involving education, communication, livelihood diversification, and socio-cultural change, connecting institutional responsiveness with conflict resolution and social learning.
2. **Integrated Marine Spatial Management, MPAs & Sustainable Tourism.** This family combines MPA and ecosystem-restoration pathways with tourism, shared-space, infrastructure, and pollution-management pathways. These connect ecological resilience, sediment dynamics, water quality, and shellfish health with fisher livelihood security, linking ecological protection to the management of competing coastal uses.
3. **Market Reform, Livelihood Diversification & Fair Value Transition.** This family centers on local fishing cooperatives, fair-market conditions, and livelihood diversification. Its pathways include community-supported fisheries, local seafood and gastronomy, aquaculture–fishery integration, and invasive-species management, with feedbacks through consumption patterns, livelihood security, and the continued viability of small-scale fisheries.
4. **Real-time Science, Knowledge Integration & Stakeholder Communication.** This family links scientific and local knowledge with real-time observation, adaptive regulation, and enforcement. It also includes pathways for invasive-species management and feedbacks through communication, fisher education, and livelihood security, connecting knowledge production to management responses and stakeholder participation.
5. **Sustainable Vessel Transition, Climate Adaptation & Resilient Infrastructure.** This family links cooperative and regulatory support for vessel modernization with pollution management, water quality, and fisher livelihood security. A complementary chain connects climate-driven change and extreme events with coastal infrastructure, bringing technological transition and climate adaptation into the same ecological–economic system.

In Figure D2, links belonging to these virtuous-cycle families are color-coded according to family membership. As with Figure D1, all other links were omitted.

Together, Figures D1 and D2 demonstrate that the vicious and virtuous cycles identified in Step 3 are not abstractions or reconstructions external to the mapping process. Rather, they are substructures of the same combined conceptual map, anchored in transcript-derived evidence, node-link consistency, and DAPSI(W)R(M) coding logic. These figures therefore complement Figure 3 by providing a complete record of all cycles and cycle families, showing that the simplified example in Figure 3 is rooted in the documented analysis of the combined map, and offering a basis for audit, replication, and methodological scrutiny.

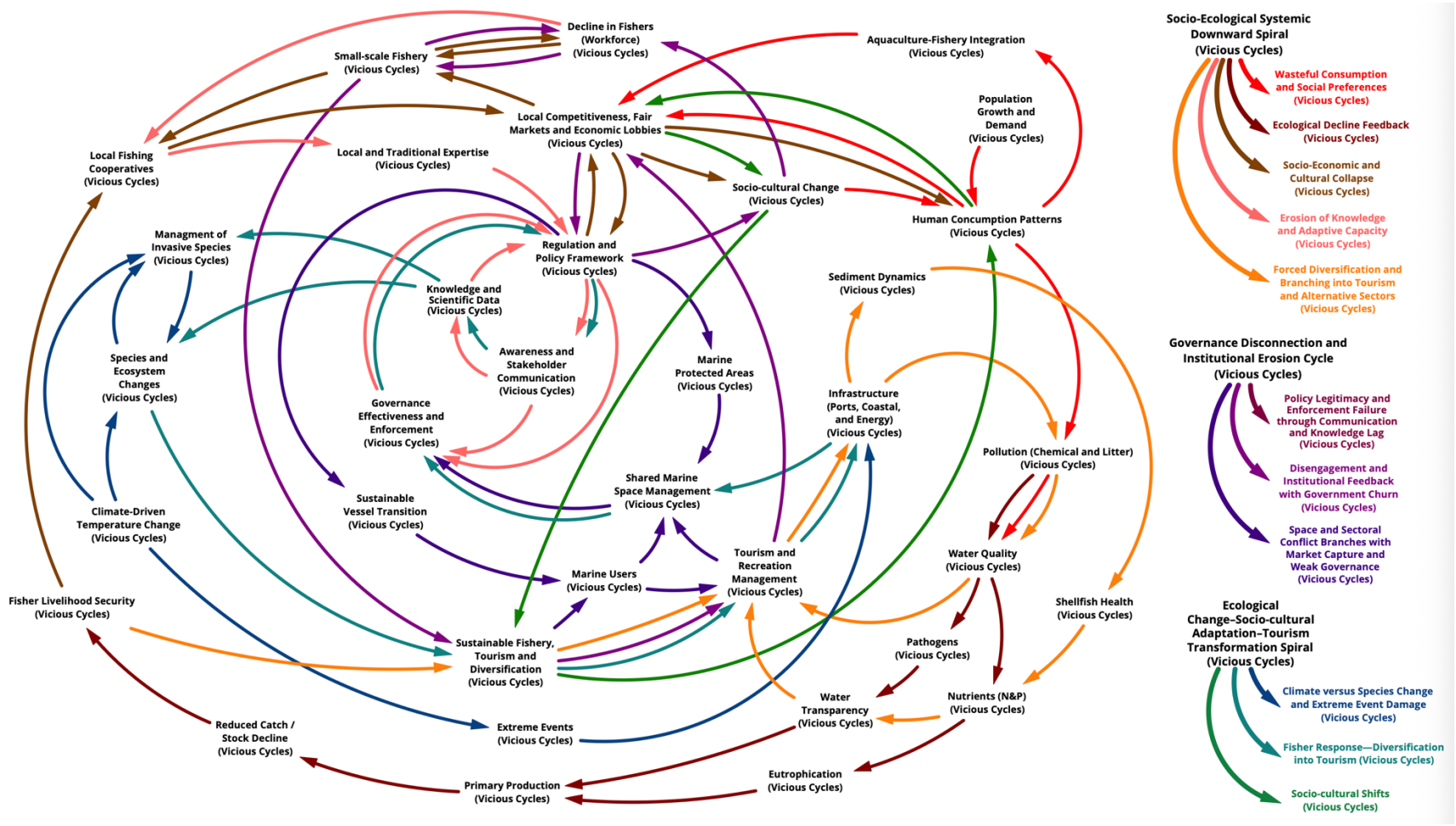


Figure D1: Full conceptual map with all vicious cycles identified in Step 3. Nodes and links correspond to the combined map produced in Step 2. Color-coded link sets indicate the eleven vicious loops and chains, grouped into three vicious-cycle systems. Only links belonging to identified vicious cycles are shown.

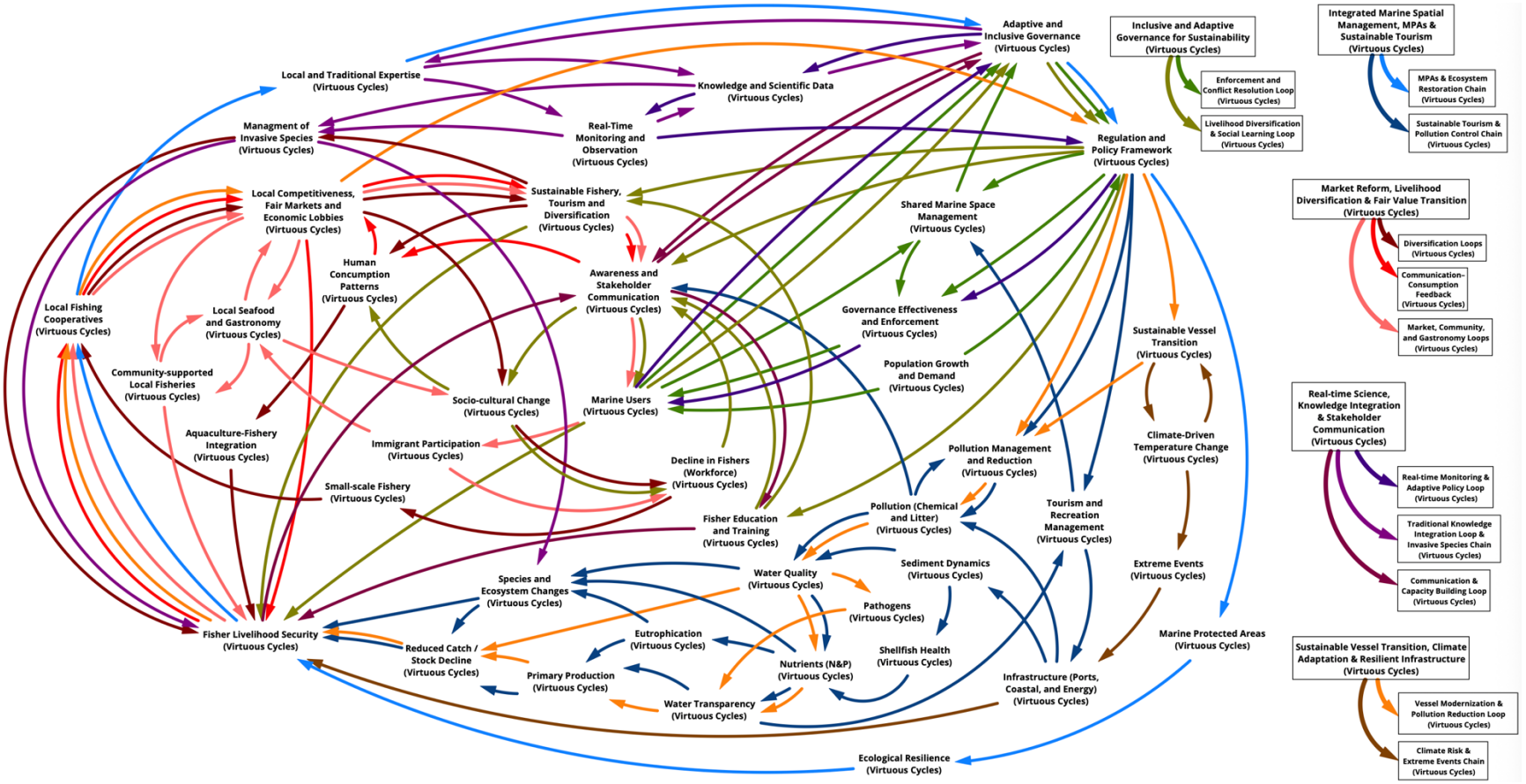


Figure D2: Full conceptual map with all virtuous cycles identified in Step 3. Nodes and links correspond to the combined map produced in Step 2. Color-coded link sets indicate the twelve virtuous loops and chains, grouped into five virtuous-cycle systems. Only links belonging to identified virtuous cycles are shown.