**Supplementary Materials:**

**Supplementary Table S1.** Conceptual evidence and theoretical contribution matrix.

| Theoretical / Contextual Domain | Evidence Role | Supporting Literature | Source-Supported Contribution | Framework Relevance | Interpretive Limitation |
|---|---|---|---|---|---|
| Geothermal investment and socioeconomic opportunities | Theoretical/sector foundation | ESMAP [1]; IEA [4]; Shortall et al. [6]; Kurek et al. [5] | Development stages, employment and procurement opportunities, sustainability concerns and community-based development | Geothermal Investment; linkage opportunities; P1 | Sectoral and theoretical background; not validation of P1 |
| Productive and direct geothermal utilization | Sector illustration | Lund and Toth [2]; Putriyana et al. [3]; Axelsson et al. [16] | Direct heat applications and technically contingent productive uses | Productive-use mechanism; potential direct pathways | Illustrates technological possibilities; does not establish Sokoria feasibility |
| Extractive-industry linkage theory | Theoretical support | Hirschman [8]; Morris et al. [9] | Backward/forward linkages, supplier development and enclave risks | Linkage formation, enclave–anchor trajectories; P1, P7 | Established theory; no geothermal-specific causal validation |
| Global value-chain governance and upgrading | Theoretical support | Gereffi et al. [7]; De Marchi and Alford [10] | Supplier upgrading, value-chain governance, capability and policy-enabled upgrading | Linkage mechanisms, Linkage Quality (depth); P2, P5 | Upgrading is established; proposed Linkage Quality combination is conceptual |
| Territorial embeddedness and regional production networks | Theoretical support | Hess [11]; Coe et al. [12] | Territorial anchoring, institutional relationships and value capture | Economic Embeddedness; P3, P4, P7 | Local ownership/reinvestment indicators are proposed operationalizations |
| Energy-transition governance and institutional capacity | Theoretical support | van Dijk et al. [22]; De Marchi and Alford [10] | Regional governance capacity and policy support for upgrading | Governance functions; institutional capacity boundary; P5–P6 | Do not infer uniform direct effects on local reinvestment |
| Social acceptance of geothermal projects | Sector illustration / contextual | Renoth et al. [31]; Kurek et al. [5] | Acceptance, participation and community-oriented development considerations | Contextual considerations for governance; not a direct outcome measure | Renoth [31] does NOT establish governance → local reinvestment |
| Geothermal project uncertainty and territorial absorptive capacity | Theoretical/contextual support | Hartono et al. [13]; Manu et al. [24]; IEA [4] | Exploration uncertainties, variation in absorptive capacity, project-phase differences | Territorial capability and project temporal dynamics; P6 | Context-sensitive; African absorptive-capacity study not direct Sokoria evidence |
| International geothermal experiences | Sector illustration | Hughes and Rogei [14]; Ratio et al. [15]; Axelsson et | Community distribution concerns, stakeholder engagement, | Geothermal specificity and context-dependent opportunities | Studies in distinct countries do not empirically verify P1–P7 |

| Theoretical / Contextual Domain | Evidence Role | Supporting Literature | Source-Supported Contribution | Framework Relevance | Interpretive Limitation |
|---|---|---|---|---|---|
| | | al. [16]; Taute et al. [17] | direct use and multi-criteria impact assessment | | |
| Indonesia and Sokoria geothermal context | Sector illustration / institutional documentation | Chelminski [18]; Ahimsa [19]; ESDM [20–21] | Investment policy, community advocacy, announced Sokoria development and documented operating context | Illustrative Sokoria vignette; Indonesian boundary considerations | No verified supplier continuity, local ownership, reinvestment or trajectory classification |
| Indonesian policy and legal framework | Policy/legal context | MEMR Regulation 11/2024 [26]; MEMR Decree 191/2024 [27]; Government Regulation 28/2016 [28]; MEMR Regulation 23/2017 [29]; Law 21/2014 [30] | Domestic content requirements, geothermal production bonuses and regulatory setting | Policy implications; coordination and institutionalization; P5 contextualization | National TKDN ≠ host-region procurement; bonus revenue not automatically earmarked for MSMEs |
| Conceptual model-development methodology | Methodological support | Jaakkola [23]; Naeem et al. [24] | Conceptual model development and an example of thematic analysis methodology | Methods and theoretical synthesis transparency | Naeem does not prove formal coding was performed in this study |

Note: Evidence roles are distinguished as theoretical support, sector illustration, policy/legal context, and methodological support. The matrix maps cited publications to their defensible analytical functions; it is not a systematic-screening inventory or evidence that the proposed propositions have been validated. Renoth et al. [31] informs geothermal social acceptance and does not establish a causal effect of governance on local reinvestment. Project-specific claims about Sokoria remain secondary-source illustrations, not primary empirical results.

**Supplementary Table S2.** Theoretical derivation and conceptual boundaries of linkage quality.

| Theoretical Rationale | Proposed Dimension | Boundary (Not Embeddedness) | Observable Relational Manifestation |
|---|---|---|---|
| Supplier learning, technical skill acquisition, process or product upgrading, and higher-value participation are relational capability developments. Conceptual support: Gereffi et al. [7]; De Marchi and Alford [10]. | Depth | Measures capability change within investment-linked economic relationships; excludes ownership of firms/assets, local profit retention, and territorial decision-making. | Verified improvements in supplier certifications, product/process standards, technical competencies, or higher-value tasks among participating suppliers/workers. |
| Economic relationships may continue across procurement cycles or project phases, independent of their ownership or where resulting benefits are spent. Sectoral context: ESMAP | Durability | ONLY continuity of employment, supplier, service, or collaborative relationships across defined periods. Excludes persistence of “associated benefits”, local | Proportion of eligible supplier relationships renewed; contract duration (months); continuation of verified employment or service |

| Theoretical Rationale | Proposed Dimension | Boundary (Not Embeddedness) | Observable Relational Manifestation |
|---|---|---|---|
| [1]; geothermal project phases [4,13]. | | reinvestment, asset ownership, and institutional embedding. | relationships across construction-to-operation transition. |
| The range and distribution of participation across eligible workers, enterprises, and types of economic activity can differ even when total procurement is similar. Support: ESMAP [1]; Kurek et al. [5]; De Marchi and Alford [10]. | Breadth | Measures reach/distribution of project-linked participation, not ownership/control of enterprises and not changes in regional sectoral diversification (an outcome of transformation). | Share or distribution of eligible local supplier and worker categories participating in project-linked opportunities; enterprise participation diversity. |
| Production-network and GVC perspectives motivate functional complementarity among training, procurement, enterprise upgrading, infrastructure, productive heat use, and market links. Support: Gereffi et al. [7]; Coe et al. [12]; Lund and Toth [2] for direct-use context. | Interconnection | ONLY functional linkages or complementarities BETWEEN TWO OR MORE economic linkage mechanisms; excludes integration "within host-region productive systems" as territorial embeddedness, local ownership, reinvestment, or local decision authority. | Documented supplier-training-to-procurement pathways; joint initiatives spanning procurement and upgrading; measurable cross-mechanism network ties or referrals. |

**Note.** The four dimensions are theory-derived relational specifications, not categories produced by a documented systematic coding or frequency-analysis procedure. Durability refers only to continuity of economic relationships; interconnection only to complementarities among linkage mechanisms. Local beneficial ownership, control over productive assets, reinvestment of earnings, and territorial strategic decision-making are excluded from Linkage Quality and belong to Economic Embeddedness. Regional diversification and productivity are outcomes of Local Economic Transformation. All proposed indicators require future empirical validation.

**Supplementary Table S3.** Comparative theoretical positioning of the policy-enabled conceptual framework.

| Prior Framework / Source | Established Contribution | What The Proposed Framework Retains | Bounded Contribution / Distinction |
|---|---|---|---|
| Hirschman [8]; Morris et al. [9] | Backward/forward linkages, industrial development opportunities, and risks of enclave formation in resource-based sectors. | Linkage formation; resource-based supplier relationships; enclave–anchor problem. | Differentiates linkage formation from relational quality and territorial control; considers geothermal project phases. |
| ESMAP [1] | Geothermal socioeconomic benefit categories, including employment, skills, domestic participation, and community benefits. | Relevant benefit categories and potential local economic transmission channels. | Explains proposed relationships among linkage mechanisms, Linkage Quality, and territorial anchoring; does not claim discovery of benefit categories. |
| Shortall et al. [6] | Assessment of geothermal sustainability impacts and evaluation frameworks. | Environmental, social, and development context for geothermal sustainability. | Narrower mechanism-oriented account of local productive transformation, not a replacement for sustainability assessment. |
| Kurek et al. [5] | Community-based approaches to geothermal development and the importance of local participation and endogenous development. | Community and territorial considerations relevant to geothermal host regions. | Does not claim community-based geothermal development is novel; separates participation, relational quality, local ownership/reinvestment, and outcomes. |
| GVC governance: Gereffi et al. [7] | Value-chain governance, supplier relationships, upgrading opportunities, and production organization. | Enterprise participation, upgrading, and value-capture logic. | Specifies a four-dimensional proposed Linkage Quality construct and differentiates it from territorial embeddedness. |
| State policy and upgrading: De Marchi & Alford [10] | State policies and upgrading in global value chains; roles of policy interventions and institutional conditions. | Policy-enabled capability formation and upgrading; governance relevance. | Differentiates coordination, capability enabling, and institutionalization by target relationship; does not claim state-led upgrading is newly discovered. |

| Prior Framework / Source | Established Contribution | What The Proposed Framework Retains | Bounded Contribution / Distinction |
|---|---|---|---|
| Embeddedness/GPN: Hess [11]; Coe et al. [12] | Spatial embeddedness, regional production networks, and territorial development relationships. | Local anchoring, territorial productive control, and regional value retention. | Separates relational Linkage Quality indicators from beneficial ownership, local reinvestment, and strategic decision-making; prioritizes test of P3. |
| Proposed Policy-Enabled Framework | Integrative conceptual model; not an empirically validated causal theory. | Five constructs, six linkage mechanisms, geothermal temporal dynamics, and three governance functions. | Specific contribution: analytical construct separation; mechanism-to-governance alignment; geothermal phase sensitivity; directional and refutable P1–P7, especially P3. |

Note. This comparison identifies the principal analytical emphases of prior literature rather than claiming those approaches exclude other pathways. Earlier scholarship already addresses extractive linkages, community-based geothermal development, state policy and upgrading, and territorial embeddedness. The proposed novelty is limited to differentiated construct roles, geothermal-sensitive mechanism and phase specification, targeted governance pathways, and refutable propositions—particularly P3 (Linkage Quality → Economic Embeddedness). Neither the framework nor its indicators have been empirically validated.