

Rare Earths and Culture:

Twins with Different Mothers

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Abstract

This article develops a strategic framework for understanding culture as a national asset and a primary layer of social and economic organization. It uses rare-earth supply chains as a comparative case, not because culture resembles a mineral resource, but because both cases demonstrate a distinction between abundance and strategic capacity. Rare-earth elements acquire geopolitical and economic significance through the systems that identify, separate, refine, manufacture, govern, and distribute them. Culture likewise becomes a durable source of collective capability only when communities and institutions can interpret, steward, apply, circulate, and retain value from it. Culture shapes trust, legitimacy, identity, demand, adoption, belonging, and influence, yet public policy often confines it to the narrower categories of entertainment, heritage, tourism, or the creative industries. This article argues that such treatment obscures culture's infrastructural role and leaves societies dependent on platforms, institutions, and value chains controlled elsewhere. It proposes a cultural value chain extending from living practice through interpretation, stewardship, application, and value realization; defines cultural sovereignty as agency within exchange rather than isolation; and identifies the institutional capacities needed to support it. Human-Centered Systems is introduced provisionally as one possible research and systems-development response, not as proof

of the article’s larger thesis or as a complete infrastructure for culture. The argument
concludes that cultural abundance, like material abundance, does not produce strategic
autonomy by itself. Long-term value depends on the institutions through which an
asset is recognized, governed, developed, and shared.

Keywords: culture, rare earths, cultural sovereignty, strategic infrastructure, cultural
economy, industrial capacity, platform power

1 Introduction

Some of the most consequential assets are overlooked precisely because they appear to be
everywhere. Abundance creates familiarity, and familiarity can conceal dependence. A society
may possess a resource in substantial quantities while lacking the institutional capacity to
recognize its significance, transform it into useful capability, govern its development, or retain
a fair share of the value it generates. Under these conditions, possession is not the same as
power.

Rare-earth elements offer a useful strategic lesson. Their importance does not arise
simply from whether they exist beneath a nation’s territory. It arises from the chain of
knowledge, processing, manufacturing, regulation, finance, and coordination that makes them
usable. A country may have geological deposits and still depend on another country for
separation, refining, component production, or technical expertise. The strategic asset is
therefore not merely the material. It is the organized capacity surrounding the material
(National Research Council, 2008; U.S. Geological Survey, 2026; International Energy Agency,
2026).

Culture presents a comparable problem of recognition. It is abundant, embedded in
ordinary life, and continuously produced through language, memory, ritual, design, storytelling,
music, food, belief, style, humor, social expectation, and collective practice. Because culture
is pervasive, it is often treated as atmosphere rather than infrastructure. When it enters

economic analysis, it is commonly reduced to a set of industries or outputs: films, museums,
45 festivals, tourism, publishing, fashion, or national branding. These activities matter, but they
reveal only a portion of culture’s function (Throsby, 2001; UNESCO, 2022).

Culture is also a system through which people assign meaning, recognize authority,
form trust, imagine futures, coordinate behavior, and decide what is desirable or legitimate.
It conditions the reception of technology, the credibility of institutions, the formation of
50 demand, the cohesion of groups, and the stories through which economic and political choices
become intelligible (Swidler, 1986; North, 1990; Akerlof and Kranton, 2000). In this sense,
culture is not a decorative by-product of an economy. It is one of the layers through which
an economy and a society become possible.

This article asks: how can the rare-earth supply-chain lesson illuminate the need to
55 treat culture as strategic national infrastructure, and what institutional capacities are required
to develop culture ethically into long-term social and economic value? Its answer is that
cultural abundance becomes strategic capability only through institutions that can interpret,
steward, apply, distribute, and govern it while protecting the agency of the communities from
which it emerges.

60 The comparison has strict limits. Rare earths are nonhuman materials; culture is
a living and contested field of meaning produced by persons and communities. Mineral
processing can be discussed without attributing rights to the mineral. Cultural development
cannot be separated from the dignity, consent, ownership, and self-determination of cultural
participants. The purpose of the analogy is therefore not to invite cultural extraction. It
65 is to expose the institutional gap between possessing an asset and having the capacity to
benefit from it responsibly.

The argument proceeds from a statement of analytical method to the rare-earth
comparative case, the strategic functions of culture, a proposed cultural value chain, the
institutional requirements of cultural sovereignty, and a provisional account of Human-
70 Centered Systems. The discussion then assesses the uses and limits of the analogy before

drawing policy and research implications.

2 Analytical Approach

This article is a work of interdisciplinary conceptual analysis. It does not claim that mineral supply chains and cultural systems are empirically equivalent. Instead, it uses a structured
75 analogy to identify an institutional pattern: an asset may be abundant while the capabilities required to recognize, transform, govern, distribute, and retain value from it remain scarce or externally controlled. The comparison is theory-building rather than predictive. Its purpose is to generate questions about capacity and dependence that conventional sector-based accounts of culture may overlook.

80 The analysis brings four literatures into conversation. Research on mineral criticality and rare-earth supply chains establishes the distinction between physical availability and reliable access to processed, usable inputs (National Research Council, 2008; Wübbcke, 2013; International Energy Agency, 2026). Cultural economics distinguishes cultural value from, while relating it to, economic value (Throsby, 2001). Cultural sociology and institutional
85 economics explain how meanings, identities, norms, and formal rules shape action and exchange (Swidler, 1986; North, 1990; Akerlof and Kranton, 2000). Cultural-policy, platform, and rights frameworks locate these processes within systems of production, distribution, governance, and self-determination (UNESCO, 2005, 2022; Nieborg and Poell, 2018; United Nations General Assembly, 2007; Carroll et al., 2020).

90 Across these literatures, the article examines four dimensions: abundance, transformation capacity, governance, and value retention. Historical and policy claims about rare earths are treated as empirical premises supported by the cited literature. The transfer of those dimensions to culture is an interpretive analogy. Recommendations concerning cultural sovereignty and infrastructure are normative propositions, while Human-Centered Systems is
95 a prospective design framework. Keeping these evidentiary statuses separate is necessary to

prevent a suggestive analogy from being mistaken for proof.

3 Rare-Earth Supply Chains as a Comparative Case

3.1 Not Rare, but Strategic

The label “rare earths” can be misleading. The group comprises scandium, yttrium, and
100 the lanthanides, many of which are relatively abundant in the Earth’s crust. The strategic
problem is not uniform geological scarcity but the uneven distribution of economically viable
deposits, separation and refining capacity, environmental management, technical knowledge,
and downstream manufacturing. Their usefulness depends on a sequence of specialized
activities rather than on extraction alone (U.S. Geological Survey, 2026; National Research
105 Council, 2008).

This distinction changes how strategic resources should be understood. A deposit is a
potential input. A functioning supply chain is a capability. Between the two lie exploration,
extraction, chemical separation, refining, alloying, component production, logistics, standards,
environmental management, skilled labor, research, and long-term investment. Weakness at
110 any critical point can create dependence even when raw material is available domestically.

The larger lesson is that value accumulates around organized transformation. Raw
abundance can be exported cheaply while higher-value knowledge, processing, and manu-
facturing are concentrated elsewhere. The actor that coordinates the chain can influence
prices, standards, access, technological development, and the distribution of risk. Strategic
115 leverage therefore belongs not only to whoever possesses the resource, but also to whoever
has built the systems that make it useful. The contemporary project pipeline illustrates
this imbalance: announced diversified mining capacity outside China substantially exceeds
planned separation, refining, alloy, and magnet capacity, leaving downstream manufacturing
as the principal bottleneck to diversification (International Energy Agency, 2026).

120 Figure 1 summarizes the progression from geological abundance to strategic leverage.

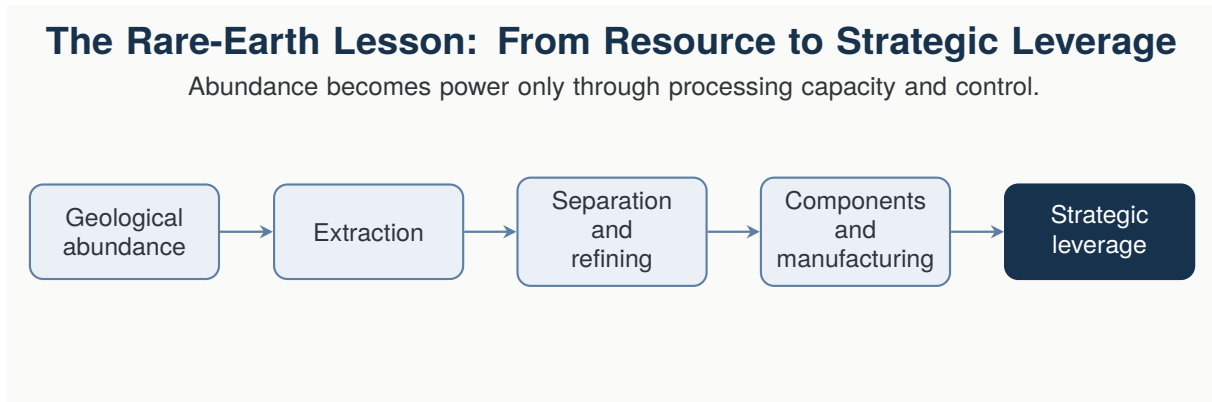


Figure 1: The Rare-Earth Lesson: From Resource to Strategic Leverage.

3.2 Foresight, Industrial Capacity, and Leverage

“The Middle East has oil; China has rare earths.”

—Deng Xiaoping, January 1992 (China National Radio, 2007)

Deng’s widely cited remark is often used to frame the modern geography of rare-
 125 earth capacity as a contrast between sustained industrial prioritization and short-term
 market calculation. Chinese rare-earth policy combined resource conservation, environmental
 regulation, industry consolidation, export controls, and the development of downstream
 industry; it cannot be understood through export restrictions alone (Wübbecke, 2013). Firms
 and governments elsewhere often accepted concentrated foreign supply when it appeared less
 130 costly. Over time, cost advantages interacted with accumulated expertise, infrastructure,
 environmental tradeoffs, and downstream manufacturing to produce concentrated capacity.
 The resulting tensions were visible in the World Trade Organization dispute over Chinese
 restrictions on exports of rare earths, tungsten, and molybdenum (World Trade Organization,
 2014).

135 This history should not be reduced to a story of national foresight on one side and
 simple negligence on the other. Industrial concentration usually emerges from interacting
 policy choices, commercial incentives, labor and environmental conditions, technological
 learning, and demand. Nevertheless, the outcome illustrates a recurring strategic pattern.

When a society evaluates an activity only through its immediate market price, it may discount
140 the option value of retaining knowledge, facilities, and coordination capacity. Capabilities
that appear redundant in ordinary periods can become indispensable when supply is disrupted
or political conditions change.

Industrial capacity is cumulative. It takes time to educate specialists, develop tacit
knowledge, permit facilities, establish standards, build supplier networks, and earn the
145 confidence of downstream manufacturers. Once dispersed, this ecosystem cannot be recreated
merely by declaring it important. Late recognition is expensive because the relevant asset is
not a single mine or factory that can be switched on. It is a network of mutually reinforcing
capabilities.

3.3 The Cost of Late Recognition

150 Strategic dependence develops when control over transformation is ceded incrementally. Each
individual decision may appear rational: import a lower-cost input, close an uncompetitive
facility, reduce public investment, or rely on a globally efficient supplier. The cumulative
effect becomes visible only when a disruption exposes how many stages of the chain can no
longer be performed domestically or through trusted partners.

155 The cost is not limited to supply shortages. Dependence can narrow policy choices,
weaken bargaining power, transfer learning opportunities, and separate producers of raw
inputs from the higher-value activities built upon them. It may also externalize environmental
damage to communities with less power to resist it. A serious strategic analysis must therefore
ask who performs each stage, who bears its risks, who owns the knowledge, and who captures
160 the resulting value.

Three principles follow. First, abundance without processing capacity does not
guarantee autonomy. Second, markets do not always price resilience, learning, or long-term
institutional capability adequately. Third, rebuilding after a crisis is more difficult than
maintaining a diverse base of knowledge and production beforehand. These principles provide

165 the strategic foundation for the comparison with culture.

4 Culture as an Overlooked Strategic Asset

4.1 Culture Is Not a Sector

Public institutions often locate culture within a ministry, budget category, or collection of creative industries. This administrative treatment is understandable, but conceptually
170 narrow. It identifies organizations that produce explicitly cultural goods while overlooking the cultural processes operating through education, technology, commerce, public health, diplomacy, urban development, and political life. International cultural-policy frameworks similarly recognize that cultural activities and services convey symbolic meaning irrespective of their commercial value and depend on systems of creation, production, dissemination, and
175 access (UNESCO, 2005, 2022).

For the purposes of this article, culture is a high-order human coordination system composed of shared and contested meanings, values, symbols, memories, identities, practices, and forms of emotional reinforcement. Culture does not eliminate disagreement. Rather, it supplies many of the repertoires, narratives, and expectations through which action
180 and disagreement become possible (Swidler, 1986). It helps people identify who “we” are, what conduct is admirable, which institutions deserve confidence, and which futures can be imagined.

Calling culture a primary economic layer does not mean that every cultural relationship should be monetized. It means that economic action is already culturally mediated. Trust
185 affects exchange. Identity affects affiliation and consumption. Narratives affect investment and risk perception. Social legitimacy affects whether policies, products, and technologies are adopted. Design and symbolism affect how objects are interpreted. Informal norms affect cooperation in ways that contracts alone cannot secure (North, 1990; Akerlof and Kranton, 2000; Throsby, 2001).

190 The sector model measures visible outputs. The infrastructure model asks what culture makes possible across sectors. Both perspectives are useful, but they answer different questions. The first estimates the contribution of designated cultural industries. The second investigates how systems of meaning shape coordination, participation, and value throughout society.

195 **4.2 The Abundance of Culture**

Every community generates cultural knowledge. It appears in inherited practices and new forms, in official institutions and informal networks, in local memory and global exchange. Yet abundance does not ensure recognition. Some cultural forms are documented, financed, and distributed widely; others remain illegible to dominant institutions or are appropriated
200 without meaningful participation by their originating communities.

The treatment of culture as entertainment alone obscures its role in belonging and public meaning. The treatment of culture as heritage alone can freeze living practice into an image of the past. The treatment of culture as tourism can prioritize visitor consumption over community continuity. The treatment of culture as branding can detach symbols from
205 the social relationships that sustain them. None of these uses is inherently illegitimate, but each becomes inadequate when it substitutes for a fuller account of cultural capability.

Cultural abundance also generates vulnerability. Digital platforms can distribute cultural expression at unprecedented scale while centralizing discovery, data, revenue, and rule-setting. Platformization makes cultural commodities contingent on infrastructures and
210 markets whose governance is largely external to individual creators (Nieborg and Poell, 2018). Creators and communities may supply the meanings that attract attention without controlling the infrastructures through which attention is monetized. Cultural value can therefore travel globally while benefits remain concentrated in platform owners, intermediaries, or institutions distant from its source (UNESCO, 2022, 2026).

215 The strategic question is not whether culture should circulate. Circulation is one of

the ways culture lives and changes. The question is whether communities possess sufficient knowledge, rights, organizational capacity, and bargaining power to participate in that circulation on fair terms.

5 The Cultural Value Chain

5.1 From Living Culture to Capability

If culture is treated only as an object to preserve, policy will concentrate on archives, monuments, and authorized traditions. Preservation is essential, particularly where memory or language is endangered, but a living culture also requires the capacity to interpret inherited material, contest it, recombine it, and apply it to new circumstances. Strategic cultural policy must therefore join continuity with development.

A provisional cultural value chain, informed by the distinction among creation, production, dissemination, distribution, and access in international cultural policy, can be described in five stages (UNESCO, 2005, 2022):

1. **Living culture:** the practices, languages, memories, relationships, and creative acts through which people produce meaning.
2. **Interpretation and research:** the work of documenting, studying, translating, contextualizing, and debating cultural knowledge.
3. **Stewardship and governance:** the institutions, norms, rights, and decision processes that determine who may preserve, use, alter, authorize, or benefit from cultural material.
4. **Application and circulation:** the use of cultural knowledge in education, media, design, technology, public policy, diplomacy, community development, and markets.
5. **Social and economic capability:** the trust, belonging, learning, influence, livelihood, institutional legitimacy, and adaptive capacity that may result.

Figure 2 presents these stages as a cultural-development sequence.

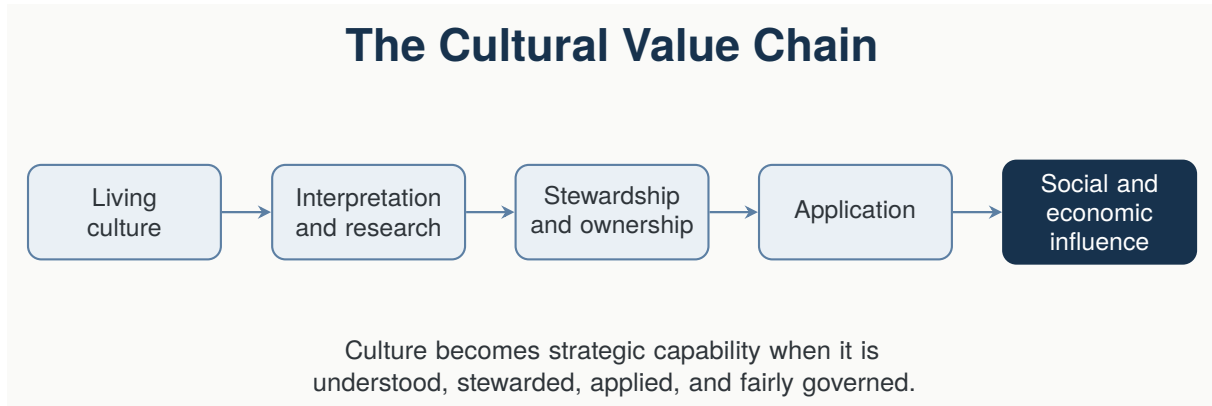


Figure 2: The Cultural Value Chain.

The word “chain” should not imply a one-way industrial pipeline. Cultural creation is recursive. Applications reshape living practice; research changes interpretation; circulation creates new communities; and governance decisions alter who can participate. A network or ecosystem may ultimately be the more accurate model. The value-chain language is retained here because it forces attention to transitions at which knowledge, authority, revenue, and control can be lost.

At every stage, the central analytical questions are the same: Who contributes? Who interprets? Who decides? Who owns or controls the relevant infrastructure? Who bears risk? Who receives recognition? Who captures financial and nonfinancial value? These questions turn a general celebration of culture into an analysis of institutional capacity.

5.2 Culture as Strategic Infrastructure

Infrastructure is commonly imagined as the material systems beneath social activity: roads, electricity, water, telecommunications, and logistics. Culture differs because it is not a neutral substrate installed by engineers. It is lived, plural, and politically contested. Nevertheless, the infrastructural concept is useful when it directs attention to enabling conditions rather than isolated products.

Cultural infrastructure includes visible institutions such as schools, libraries, archives, museums, media organizations, studios, performance spaces, and community centers. It also includes less visible arrangements: language access, research methods, intellectual-property rules, customary rights, public funding, professional networks, digital standards, platform governance, and the capacity to evaluate cultural effects. Together these arrangements influence which cultural forms are legible, which can circulate, and whose claims are recognized (UNESCO, 2022, 2026).

The rare-earth comparison becomes most useful at this point. Cultural expression is analogous not to ore, but to an abundant potential whose strategic effects depend on surrounding capabilities. Interpretation performs some of the work that technical knowledge performs in a material supply chain. Stewardship and rights frameworks establish legitimate control. Education and media provide channels of application and distribution. Finance supplies time and organizational durability. Governance determines how risks and benefits are shared.

The analogy also reveals a danger. If institutions approach culture only as an input to be processed, they may reproduce extractive relations. Strategic cultural infrastructure must therefore be judged not only by how much value it produces, but by whether it expands the agency of cultural participants. Its purpose is not to convert all meaning into property. Its purpose is to ensure that communities can decide how their cultural knowledge is preserved, developed, shared, withheld, or rewarded.

Figure 3 makes the structural comparison explicit while retaining the distinct sources and ethical conditions of value.

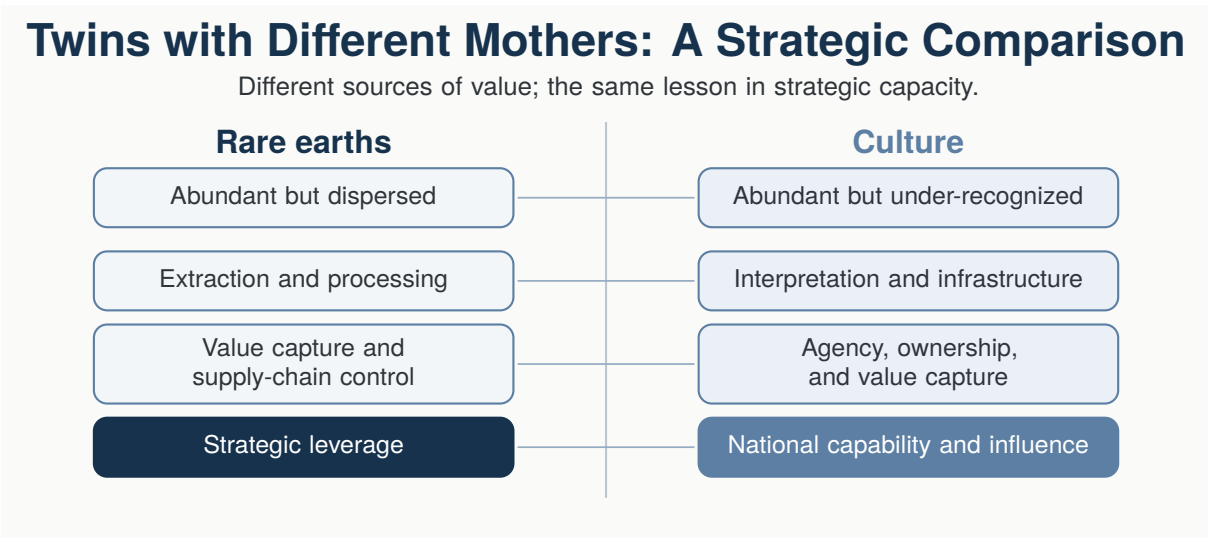


Figure 3: Twins with Different Mothers: A Strategic Comparison.

6 Cultural Sovereignty and Institutional Capacity

6.1 Cultural Sovereignty

280 Cultural sovereignty is the capacity of people and communities to preserve, interpret, develop, share, and benefit from cultural resources on fair and self-determined terms. It is not cultural isolation, purity, or immunity from influence. Cultures have always developed through movement, encounter, borrowing, conflict, and exchange. Sovereignty concerns the conditions of participation in those processes. This formulation draws on international commitments to

285 cultural diversity and on the rights of Indigenous peoples to maintain, control, protect, and develop cultural heritage, traditional knowledge, and cultural expression (UNESCO, 2005; United Nations General Assembly, 2007).

This distinction matters because national strategy can easily become a language of enclosure. A government might invoke cultural protection to centralize authority, suppress

290 internal diversity, or define an official identity that excludes minority communities. A rights-respecting account of cultural sovereignty must therefore operate at multiple levels: individual, community, Indigenous, local, national, and transnational. Claims at one level cannot automatically erase claims at another. The CARE principles—Collective Benefit,

Authority to Control, Responsibility, and Ethics—provide one relevant model for centering
295 collective rights and self-determination in the governance of knowledge and data (Carroll
et al., 2020).

Nor should the phrase “national asset” imply state ownership of culture. It identifies
culture as a matter of national significance and public capability, not as property that a
government may appropriate. The state may fund, protect, coordinate, and regulate, but
300 legitimate stewardship requires representative institutions and meaningful participation by
the people whose practices and knowledge are at stake.

Cultural sovereignty can thus be understood as agency within interdependence. A
sovereign cultural system is capable of exchange without being structurally compelled to
surrender all control over interpretation, distribution, data, or value capture. It can welcome
305 circulation while maintaining the institutional means to negotiate its terms.

6.2 Building the Capacity

If culture is strategic infrastructure, symbolic recognition is insufficient. Capacity must be
built across a connected institutional field. At least eight components require attention.

First, *research and archives* are needed to document cultural histories and living
310 practices without treating documentation as a substitute for community authority. Second,
education and cultural intelligence are needed so that citizens, officials, designers, and
organizations can interpret cultural contexts rather than relying on stereotypes. Third,
creator and community support must provide time, space, training, health, and organizational
resources, not merely prizes for a small number of visible outputs.

315 Fourth, *ownership and rights frameworks* must address copyright, collective and
customary interests, attribution, consent, cultural data, and forms of knowledge that do
not fit conventional intellectual-property categories. Fifth, *cultural finance* must support
patient and community-accountable development rather than requiring immediate commercial
scale. Sixth, *media and distribution capability* must reduce dependence on a small number of

external gatekeepers while preserving access to global audiences.

Seventh, *representative governance* must include creators, communities, researchers, public institutions, and affected groups in decisions about cultural development. Eighth, *ethical evaluation* must examine distributional and cultural effects alongside conventional economic returns. Measures of revenue or audience size cannot by themselves reveal whether an initiative strengthened language continuity, community agency, public trust, or fair participation.

Figure 4 organizes the principal institutional requirements between the foundation of living culture and the desired capability outcomes.

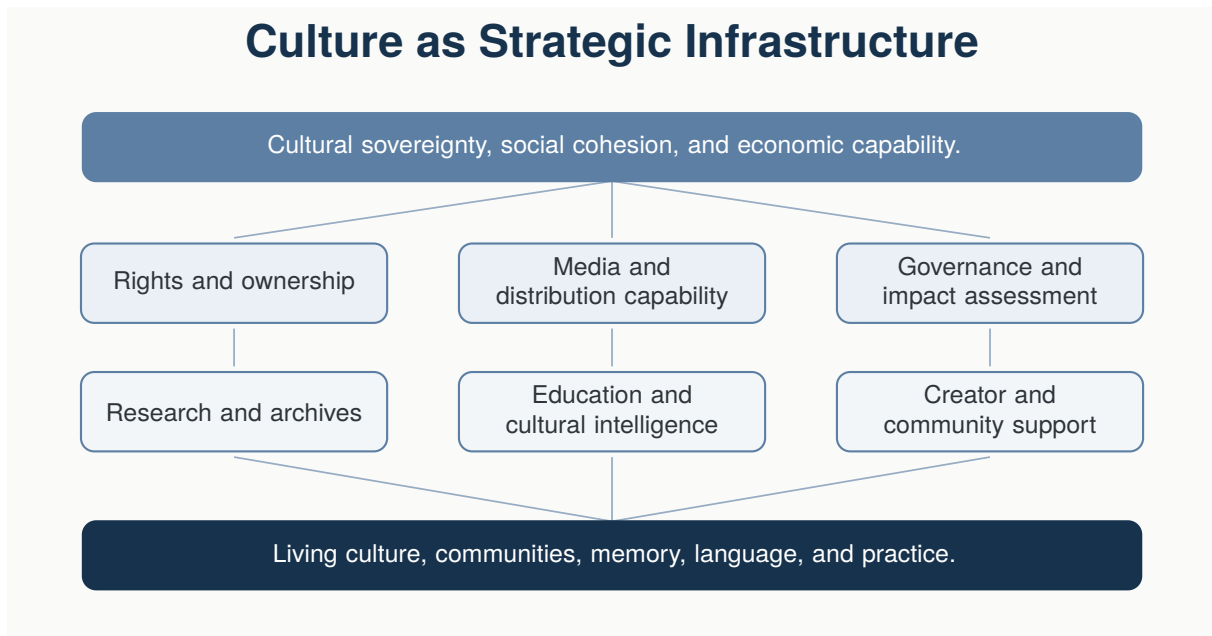


Figure 4: Culture as Strategic Infrastructure.

These components are mutually dependent. Rights without enforcement have little effect. Archives without access or living participation can become repositories of disconnected material. Funding without governance can intensify elite capture. Distribution without bargaining power can increase visibility while worsening dependency. The objective is therefore not a list of cultural programs but an institutional ecosystem capable of learning and coordination. Research on collective governance further suggests that legitimate rules,

335 monitoring, participation, and nested institutions matter for sustaining shared resources across scales (Ostrom, 1990).

National governments have an important role, but capacity should not be equated with centralization. Municipal institutions, universities, community organizations, public-service media, cooperatives, private firms, and transnational networks may each perform necessary
340 functions. The appropriate institutional mix will vary by history and political context. What matters is whether the system as a whole enables cultural participants to exercise agency and retain a meaningful share of the value they help create.

7 A Proposed Infrastructure Response

7.1 Human-Centered Systems

345 Human-Centered Systems (HCS) are defined within the CVEST research program as “computational, commercial, and experiential systems that make culture engineerable, deliverable, measurable, and rewardable as a primary market offering” (Khanyile, 2026a, p. 24). The category is intended to differ from entertainment platforms, social networks, advertising technologies, and recommendation systems because it treats culture itself—rather than content,
350 attention, or audience response—as the primary layer around which computation, interfaces, incentives, participation, and exchange are organized.

The HCS proposal begins from a process account of cultural formation. Values organize what people experience as significant; contextual signals activate or violate those values; affective and emotional responses give significance a felt and motivational form; and repeated
355 social reinforcement stabilizes meanings, symbols, rituals, and identities across groups. On this account, culture is emergent but not wholly opaque. HCS seeks to model enough of this process to support the intentional design, delivery, evaluation, and governance of cultural experiences without claiming that culture can be reduced completely to computational variables (Khanyile, 2026a, pp. 5–6).

360 The proposed architecture is a five-part stack:

1. **Sensia Quotia Computation (SQC)** is the proposed computational engine for modeling how observation and decision context are transformed through interpretation, values, existential appraisal, motivational drivers, emotional modulation, and an internal existential state before producing action.
- 365 2. **The Neural Grid** is the proposed symbolic and computational infrastructure through which significance-related computation and cultural sensation would be coordinated, distributed, measured, governed, and connected to economic activity.
3. **Human-Centered Systems** name the market and systems category that organizes interfaces, participation, incentives, and exchange around culture as the primary offering.
- 370 4. **Application ecosystems** provide interfaces through which the architecture could be encountered in practice. The HCS manuscript presents Music 2.0 as its first proposed integrated deployment, with music functioning as an interface to culture rather than solely as an endpoint product.
5. **Cultural Impact** is the proposed value outcome: the extent to which an offering alters, 375 reinforces, or deepens sensation, identity, belonging, meaning, and contribution within a culture.

Within this stack, SQC v1.2 supplies the most developed technical component. Its implementation enforces a sequential Evolutionary Psychological Structures (EPS) pathway. The action mapper receives predicted EPS-stage outputs and explicit EPS memory rather 380 than a raw observation, encoder state, or direct decision-context vector; action supervision is also prevented from rewriting the upstream psychological pathway merely to improve action classification. The design therefore tests whether behavior can be learned as the readout of an explicit internal-state sequence rather than through a direct observation-to-action shortcut (Khanyile, 2026b, pp. 1–3, 10–14).

385 The reported prototype uses 14,400 simulator-generated EPS-complete timesteps across 48 combinations of role, goal, and risk, with eight complete combinations withheld from training. On this compositional split, the balanced checkpoint reports 75.25% exact test-action accuracy, 75.00% accuracy on the withheld combinations, a 0.30 percentage-point aggregate gap between seen and unseen combinations, a 66% worst-cell floor, and a 97.17%
390 valid-action hit rate (Khanyile, 2026b, pp. 1–2, 14–16). These results provide evidence that the specified architecture is trainable, that its internal-state constraint can be enforced, and that it can recombine familiar contextual factors within its defined ontology.

The evidence remains bounded. The training trajectories are generated from the EPS theory and therefore test implementation fidelity and compositional generalization, not
395 independent confirmation of the theory’s human psychological validity. The reported results do not establish consciousness, first-person experience, reliable prediction of people in natural environments, generalization beyond the trained ontology, or operational readiness for HCS. Those claims require independently collected human behavioral, developmental, cross-cultural, and neural evidence. The SQC manuscript consequently treats the dependency as sequential:
400 the validity of downstream Neural Grid and HCS mechanisms cannot be stronger than the validation of the significance-computation mechanism on which their distinctive measurements and decisions depend (Khanyile, 2026b, pp. 16–22).

HCS also changes the proposed economic role of participants. Because culture is stabilized through expression, interpretation, amplification, curation, ritual, and commu-
405 nity formation, participants are treated as contributors to the asset rather than solely as consumers. Contribution visibility, recognition, and reward are therefore central design problems (Khanyile, 2026a, pp. 16–18). Yet making participation legible creates risks of surveillance, manipulation, addictive reinforcement, representational distortion, and unfair value capture. The HCS framework itself consequently calls for transparency, participant
410 protection, accountable allocation of visibility and benefit, and resistance to feedback loops that privilege stimulation over meaningful cultural development (Khanyile, 2026a, pp. 22–23).

This article therefore presents HCS as a program-specific, full-stack research proposition rather than as the singular infrastructure of culture or as an already validated economic system. Its concepts may inform research and prototypes before every dependency is validated, but substantive claims about measurement, prediction, or automated cultural administration must remain proportional to the available evidence. Any implementation must also preserve consent, privacy, contestability, plural forms of value, and community governance as foundational rather than optional safeguards.

Figure 5 positions HCS as one proposed response within the wider field of cultural infrastructure.

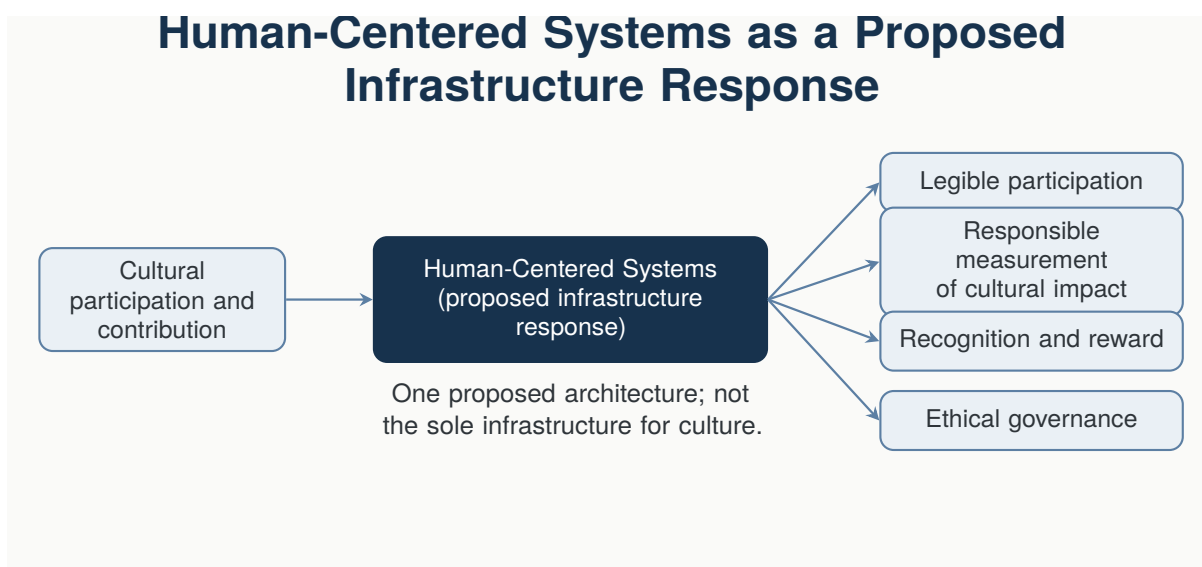


Figure 5: Human-Centered Systems as a Proposed Infrastructure Response.

7.2 Scope and Standards of Evidence

The main thesis of this article must stand independently of HCS. The strategic importance of culture follows from its role in meaning, coordination, identity, legitimacy, and value formation, together with the institutional conditions that govern those functions. A proposed system architecture may respond to this analysis, but it cannot serve as the evidence that the analysis is correct.

Future versions of the HCS argument should distinguish at least five evidentiary statuses:

1. **Conceptual architecture:** a reasoned account of components and relationships.
- 430 2. **Prototype evidence:** evidence that a limited implementation can perform specified functions.
3. **Construct validation:** evidence that concepts such as contribution, participation, or cultural impact are defined and measured coherently.
4. **Ecological validation:** evidence that the system remains meaningful in real communities
435 and institutional settings.
5. **Operational deployment:** evidence concerning governance, reliability, adoption, unintended effects, and sustainability at working scale.

Claims must not move silently from one status to another. A coherent design is not proof of social benefit. A successful prototype is not proof of general validity. Short-term
440 adoption is not proof of just governance. Accordingly, this article excludes undefined or unvalidated technical mechanisms from its substantive claims and confines HCS to the level of conceptual architecture.

The broader rare-earth and culture comparison requires similar discipline. Documented historical facts, interpretive analogies, normative recommendations, and proposed system
445 designs should be signaled clearly. Their interaction can strengthen the manuscript, but only if their different standards of evidence remain visible.

7.3 A Call to Build

Recognition without construction will not change the position of culture in public life. If culture is a strategic national asset, institutions must invest in the capabilities through

450 which it can be researched, preserved, interpreted, developed, circulated, and governed. This requires more than increased arts funding, although such funding may be part of the response. It requires coordination across education, industrial policy, media, technology, rights, finance, diplomacy, and community development.

The first task is diagnostic. Nations and communities need maps of their cultural
455 infrastructures: who produces and preserves knowledge, which institutions control distribution, where revenue and data flow, which communities are excluded, and which capabilities have become dependent on external platforms. The second task is constitutional in the broad sense: rights, responsibilities, and representative decision processes must be established before cultural value is pursued at scale. The third task is developmental: institutions must finance
460 experiments, educate practitioners, build public and community capacity, and learn from failure.

The objective is not cultural autarky. No country can or should seal its culture from exchange. The objective is the capacity to participate in exchange without becoming entirely dependent on systems whose rules are set elsewhere. This includes the ability to sustain local
465 and minority languages, support creators, negotiate with global platforms, govern cultural data, and ensure that communities share in the benefits derived from their knowledge and expression.

The rare-earth lesson warns against waiting for a crisis to reveal missing capacity. Cultural dependence may be less visible than a disrupted material supply, but it can still
470 shape whose stories circulate, which values organize technology, where creative revenue accumulates, and who possesses the data required to understand collective behavior. Building cultural infrastructure is therefore an anticipatory project.

8 Discussion: The Uses and Limits of the Analogy

The comparison developed here is valuable because it shifts attention from possession to capability. Both rare-earth resources and cultural resources can be abundant while the systems required to generate and retain value are concentrated elsewhere. In both cases, apparently efficient market arrangements may conceal losses of resilience, knowledge, bargaining power, and long-term option value. In both cases, late recognition makes reconstruction difficult.

The comparison also has limits that are ethically and analytically decisive. Rare-earth elements are finite physical inputs. Culture is generative: sharing can produce new meanings rather than simply deplete a stock. Mineral value can often be separated from the identity of those who process it. Cultural value frequently depends on relationships, histories, and communities that cannot be treated as interchangeable suppliers. Material processing aims for standardized outputs; cultural development must leave room for ambiguity, dissent, transformation, and refusal.

These differences mean that the language of strategy must be handled carefully. Strategy can justify patient investment and institutional foresight, but it can also encourage states and firms to instrumentalize culture for competition, propaganda, or extraction. The appropriate test is whether strategic treatment expands human and community capability. A policy that increases national influence while silencing cultural participants would fail this test. So would a platform that increases distribution while removing meaningful consent or concentrating nearly all value elsewhere.

The manuscript's contribution is therefore not a claim that culture should imitate mineral policy. It is a vocabulary for identifying neglected institutional capacity. The central concepts—abundance, transformation, value chains, sovereignty, resilience, and value retention—make it possible to ask how cultural systems are organized and whose interests they serve. The analogy succeeds when it reveals these questions and fails when it obscures the human relationships at their center.

9 Conclusion

500 Culture is commonly recognized as expressive, symbolic, and socially valuable, yet it is still treated as secondary to the “real” infrastructures of economic and political life. This article has argued that the distinction is misleading. Culture shapes the meanings through which institutions gain legitimacy, people coordinate, products acquire significance, technologies are adopted, and communities imagine collective futures. It is therefore not merely one sector
505 among others. It is a primary layer of social and economic capability.

The rare-earth case supplies a strategic warning. Abundance alone does not produce autonomy or leverage. Value depends on the accumulated institutions that recognize an asset, develop knowledge around it, transform it into usable forms, govern its risks, and connect it to downstream applications. When those institutions are allowed to disappear or become
510 concentrated elsewhere, recognition often arrives only after dependence has formed.

For culture, the necessary response is not extraction but stewardship. Research, archives, education, rights, finance, media, distribution, representative governance, and ethical evaluation must work together so that cultural participants can shape the conditions under which value is created. Cultural sovereignty names this capacity for agency within
515 exchange. Human-Centered Systems may contribute to that project, but it remains a proposed response whose concepts and mechanisms require independent validation.

Culture today resembles rare earths at the moment before their strategic importance became widely understood: abundant, foundational, and underdeveloped as a field of coordinated policy. Those who build legitimate institutions around culture will influence how
520 meaning, participation, and value are organized in the future. Those who continue to treat it as an after-effect may discover its importance only after the principal means of interpretation and distribution are controlled elsewhere.

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