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From Depreciation to Full Replacement Cost: Evaluating Compensation Gaps in Infrastructure Resettlement

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Abstract

The construction of large-scale infrastructure projects has a significant impact on the residents. In this study, a total of18 households that were affected by damage induced by construction activities such as blasting were considered. The owners were compensated on a depreciation-based replacement under the Building Valuation Procedure, 2070, which mentions explicitly that it can be used for compensation. The study shows that compensation is determined by a single factor of age-to-building-life ratio without consideration of physical damage to the structure. Since the international compensation frameworks including The World bank and Asian development bank excludes depreciation from replacement cost. Using the Building Valuation Procedure, 2070 and the Bagmati Province rate schedule (FY 2078/79), we reconstruct the full valuation and compare two valuations of each dwelling that differ only in the depreciation step. The consideration of mixed-structure types is done to calculate the deduction by rate; restoration adequacy between long-life (n=75) and short-life (n<75) construction classes was assessed with a Mann–Whitney U test. Depreciation deducted from compensation ranged from just 4% for a newer concrete home to 55.6% for a seven-year-old earthen house. This was due to variation in depreciation of earthen material, which depreciates at 10% per year versus 1.33% for concrete. Traditional homes received an average adequacy ratio of 0.80 for every rupee required to rebuild compared to the earthen dwelling which received just 0.44. Compensation strategies based on depreciation fall disproportionately on vernacular construction. The 9.7% depreciation gap also understates the true shortfall in compensation as transitional costs, transportation costs, lost income and other factors required under World Bank and ADB frameworks tend to remain wholly unaddressed. Inserting a no-depreciation standard into Nepal's domestic compensation procedure would be a remedial measure against this inequity at a minimal increase in overall compensation granted.

Keywords: *construction-induced damage; depreciated replacement cost; public projects; compensation equity; socio-economic impact of construction*

1. Introduction

Construction activities such as drilling and blasting transmit vibration into surrounding ground. Recent research confirms that blasting operations during construction exert significant dynamic loads on nearby structures, with the severity of structural response governed by material properties (Ren et al., 2024). For earthen and unreinforced masonry building that predominate in low-income Nepalese settlements, these responses are acutely damaging (Adhikari & D'Ayala, 2020). In the case of weak geology, it can cause settlement, subsidence, and sinkhole formation that damage nearby buildings. When such damage occurs on public projects, compensation valuation becomes a crucial factor in restoring the damage to property and safely moving and rehabilitating the affected households.

This paper analyses compensation paid to owners of 18 homes damaged within the zone of influence of a construction project in Nepal. The damage induced by construction blasting and ground subsidence was approved for full compensation by a Council of Ministers. The Land Acquisition Act, 2034 (1977) ("Land Acquisition Act," 1977) is focuses on acquiring intact land and structures for a public purpose. It does not contain a methodology for compensating structures that have been damaged by construction activity. Therefore, in the absence of a instrument which focus on construction damage, the authorities created a Building Valuation Procedure, 2070 which was is a better instrument to determine valuation for taxation purposes Currently, the Building Valuation Procedure, 2070 (DUDBC, 2013) is the main basis of valuation to compensate the project-affected area. Nepal has no instrument specifically governing compensation for construction-induced building damage. In its absence, this general valuation tool, which explicitly permits use for compensation, became the operative basis. It gives straight-line depreciation, reducing the book value with building age. International frameworks such as those of the World Bank and Asian Development Bank with the requirement of replacement cost without depreciation deductions does not incorporate into our compensation policies. Leading of displaced people into poverty is the fundamental risk in resettlement caused by development works. The relevant study on compensation and land acquisition policy of Nepal reveals that compensation is inadequate, lacks transparency in the land acquisition process, and lacks any resettlement and environmental impact provisions (Ghimire & Singh, 2024). Thus, protecting and reconstructing livelihoods of displaced people must be central requirement for development.

1.1. Governing Principle: Replacement cost without depreciation

The international principle that governs property loss or damage due to construction activities highlights the need for full replacement cost. The World Bank's ESS5 (World Bank, 2018) explicitly excludes depreciation from replacement-cost valuation and requires that compensation is sufficient to rebuild to minimum safety standards regardless of prior structure quality. The Asian Development Bank's Safeguard Policy Statement similarly mandates replacement cost without deductions for depreciation, salvageable materials, or transaction costs (Asian Development Bank, 2009). This is also reaffirmed in its 2023 Environmental and Social Framework (Zhang et al., 2023). The rationale is driven by engineering as legal context: that the damaged structures can only be repaired or rebuilt at current material and labor prices and is irrespective of age.

Nepal's Building Valuation Procedure (DUDBC, 2013) diverges at this point. Its gross value applies a depreciation factor that reduces compensation as a function of building age and the depreciation rate depends on the building type. This difference from the international standard is addressed in this paper. Studies worldwide across various infrastructure projects confirm a clear trend: when families receive insufficient compensation to rebuild their homes, they consistently suffer from poorer housing quality, increased debt burdens, and long-term social and economic marginalization (Otsuki, 2024). Research on replacement studies show that compensation or grant frameworks that fail to account for full replacement costs systematically exclude the poorest households from adequate recovery (Rawal et al., 2021).Additional literature on infrastructure related land acquisition mentions that compensation laws routinely undervalue affected property and transfers loss to displaced households where market based replacement is not practiced.(De maria et al 2023). Nepal's post-earthquake reconstruction also documents that housings developed after disasters are generally unfit for the purpose (Karki et al., 2022).

Replacement costs for lost land or assets are equal to market costs plus transaction costs (Samsul Haque & Subash, 2024). Replacement cost under these frameworks covers transaction costs, transitional housing, relocation allowances, and transitional income losses apart from structural damage. These are not fixed percentages but are determined from documented local costs and household surveys. This study isolates and quantifies the structural depreciation deduction exactly, and the remaining entitlement gaps are addressed separately. The depreciation shortfall in this paper represents a conservative lower bound on the full compensation gap.

2. Methodology

2.1. Data Sources

The primary sources are the official compensation records for the 18 fully compensated structures of the affected household. The basis of 18 households is the decision given by the Council of Ministers dated 2081/10/04 BS to compensate the fully damaged structures. The Building Valuation Procedure, 2070, from the Department of Urban Development and Building Construction (DUDBC), and the building valuation rate schedule for fiscal year 2078/79 (not amended since) for Bagmati Province were used to calculate the total cost of the structure to be compensated. Material components, the floor area, unit rate, assigned service life n, and assessed age N from records of each dwelling were collected, and Gross replacement cost and depreciated book value were calculated. To maintain confidentiality, owner names were omitted, and dwellings were assigned unique identifiers from SN-1 to SN-18.

2.2. Valuation Methods, its reconstruction and the comparison standard

Building Valuation Procedure, 2070 (DUDBC, 2013) values a building by $V = [((B.C_0 + T)(1-D)].A + O]$, in which B is the unit rate (building valuation rate schedule for fiscal year 2078/79 for Bagmati Province is used in NRs/ft^2), Co is the district coefficient (= 1.00 for Bagmati Province), T is the transport cost, A is the total floor area (ft^2), O is the value of any other structures like landscaping works, and D is the depreciation, computed as the assessed age N divided by the typology-assigned service life n (D = N/n), i.e. a fixed annual rate multiplied by age under the straight-line method prescribed by the procedure. Operationally, for each construction component the worksheet computes a gross replacement cost $C_i = B_i \cdot A_i$ (the relevant unit rate times the component area, net of any septic-tank adjustment), a straight-line annual depreciation C_i/n_i, and a depreciated book value $BV_i = C_i(1 - N_i/n_i)$. The total value of dwellings are the component sums $C = \Sigma_i C_i$ and $BV = \Sigma_i BV_i$. We adopt two assumptions consistent with the record as applied: the transport term T is set to zero, since all sites are urban and T is common to both the depreciated and the full-cost valuations and therefore cancels, and depreciation is straight-line on the assigned service life. We reconstructed this process independently for all 18 dwellings. Table 1 shows the full calculations on dwelling SN-1 as a sample calculation, isolating the depreciation factor (1 − D) as the sole element separating the compensated value from full replacement cost.

Table 1: Sample calculation as per the building valuation procedure 2070 on SN-1

Element (V = [(B·Co + T)(1−D)]·A + O)	Value
(B) unit rate (civil + electrical + sanitary), FY 2078/79	NRs 2,642.98 / ft²
(A) total floor area	2,116.14 ft²
(C_o) district coefficient (Kathmandu)	≈ 1.00
(T) transport cost (urban site)	≈ 0 (set to 0 in both methods)
Gross replacement cost (C = B·Co·A)	NRs 5,592,916
(n) assigned service life (RCC frame)	75 years
(N) assessed age	3 years
(D) depreciation = N/n = (1.33%/yr) × N	0.040 (4.0%)
Compensated value = C·(1 − D)	NRs 5,369,199

Where a house combines construction types such as an RCC frame with a CGI or UPVC enclosure, or load-bearing masonry alongside traditional earthen construction, the procedure values and depreciates each component at its own rate tier and sums the results. As per the guidelines, the values represent a 75-year life (1.33%/yr) for RCC and cement-mortar load-bearing work, a 50-year life (2.00%/yr) for CGI/UPVC elements, and a 10-year life (10.00%/yr) for traditional earthen construction.

2.3. Statistical and Scenario Analysis

To evaluate whether restoration adequacy varies significantly by depreciation service life, a comparative and scenario-based analysis was conducted between the long-life class with a service life of 75 years (n=12) and the short-life class with service life less than 75 years, based on use of composite short-life materials like CGI roofing, UPVC or earthen walls (n=6). A Shapiro–Wilk test first assessed data distribution, rejecting the assumption of normality for the short-life class ($p < 0.01$). Consequently, a two-sided Mann-Whitney U test was used as the primary non-parametric inferential statistic to evaluate differences in adequacy scores. Cliff's delta (δ) test was used as a robust, rank-based effect size to quantify ordinal dominance without parametric assumptions. Separately, a shortfall analysis evaluated the policy impact of regulatory constraints on compensation equity across six progressive depreciation caps D_{cap}: no cap; D ≤ 0.50, 0.30, 0.25, 0.20, 0.10; and D = 0). For each dwelling, revised compensation was computed as $C_{adj} = C.(1 - \min(D, D_{cap}))$, where C is the un-depreciated cost and D is the depreciation percentage. This analysis ultimately yields the aggregate financial shortfall and per-class mean adequacy for each scenario.

3. Results

3.1. Valuation driven by desk formula rather than physical condition assessment

Across the 18 buildings affected by the project, the calculated depreciation deductions varied drastically from 4.0% (SN-1) to 55.6% (SN-17) of gross replacement costs, as detailed in Table 2. Also figure 1 highlights how traditional and composite structures face significantly higher penalties compared to uniform modern houses.

Table 2: Per-dwelling valuation and depreciation for the 18 fully compensated structures.

SN	Structure type	Floor area (ft²)	Unit rate (Rs/ft²)	Repl. cost C (NRs)	Life n	Age N	Eff. N/n	Dep. rate	Book value BV (NRs)	Dep. amount (NRs)	Dep. %
1	RCC framed	2,116.14	2,642.98	5,592,916	75	3	0.040	1.33%	5,369,199	223,717	4.0
2	RCC framed	820.69	2,266.64	1,534,608	75	9	0.120	1.33%	1,350,455	184,153	12.0
3	RCC framed	779.74	2,266.64	1,368,826	75	7	0.093	1.33%	1,241,069	127,757	9.3
4	Load bearing (CGI)	526.60	2,603.54	1,081,891	75/50	11	0.166	1.51%	901,930	179,961	16.6
5	Load bearing	1,011.84	2,307.02	1,861,324	75	7	0.093	1.33%	1,687,601	173,724	9.3
6	RCC framed	1,249.84	2,642.98	3,144,300	75	4	0.053	1.33%	2,976,604	167,696	5.3
7	RCC framed	1,057.11	2,642.98	2,634,918	75	4	0.053	1.33%	2,494,389	140,529	5.3
8	RCC framed + UPVC	901.42	2,642.98	3,679,703	75/50	10 / 3	0.081	-	3,380,942	298,761	8.1
9	RCC framed	2,158.87	2,642.98	5,372,835	75	10	0.133	1.33%	4,656,457	716,378	13.3
10	RCC framed + UPVC	752.35	2,642.98	1,782,287	75/50	3	0.045	1.50%	1,702,228	80,059	4.5
11	Load bearing / CGI	374.00	1,958.53	732,490	50	10	0.200	2.00%	585,992	146,498	20.0
12	RCC + CGI	1,372.74	2,551.52	3,329,208	75/50	5	0.073	1.45%	3,087,199	242,008	7.3
13	RCC framed	2,052.63	2,642.98	4,933,042	75	5	0.067	1.33%	4,604,173	328,869	6.7
14	RCC framed	796.20	2,551.52	2,031,520	75	8	0.107	1.33%	1,814,825	216,695	10.7
15	RCC framed	1,294.10	2,642.98	3,261,278	75	7	0.093	1.33%	2,956,892	304,386	9.3
16	Load bearing	492.53	2,307.02	977,274	75	7	0.093	1.33%	886,062	91,212	9.3
17	Load bearing + earthen	629.83	2,305.07	1,292,359	75/10	7	0.556	7.94%	573,726	718,633	55.6
18	Load bearing	535.50	2,307.02	1,235,409	75	7	0.093	1.33%	1,120,104	115,305	9.3

Note: Component-wise breakdown of depreciation rate calculation is given in Annex A, where a building is made of multiple structural materials or has floors built at different times

Under Nepal's Building Valuation Procedure 2070, the amount of compensation a damaged homeowner receives is determined entirely by two parameters. First, the building's age and second, its assigned structural lifespan and not by the actual physical condition or severity of damage. The statistical relationship (R^2 = 1.00) signifies that the compensation is a mathematical identity that can be calculated even without ever stepping on site through plinth area measurements and photographs as well. The condition of the building and its damage, the required slope protection works, and other structures constructed for building stability are irrelevant to the outcome.

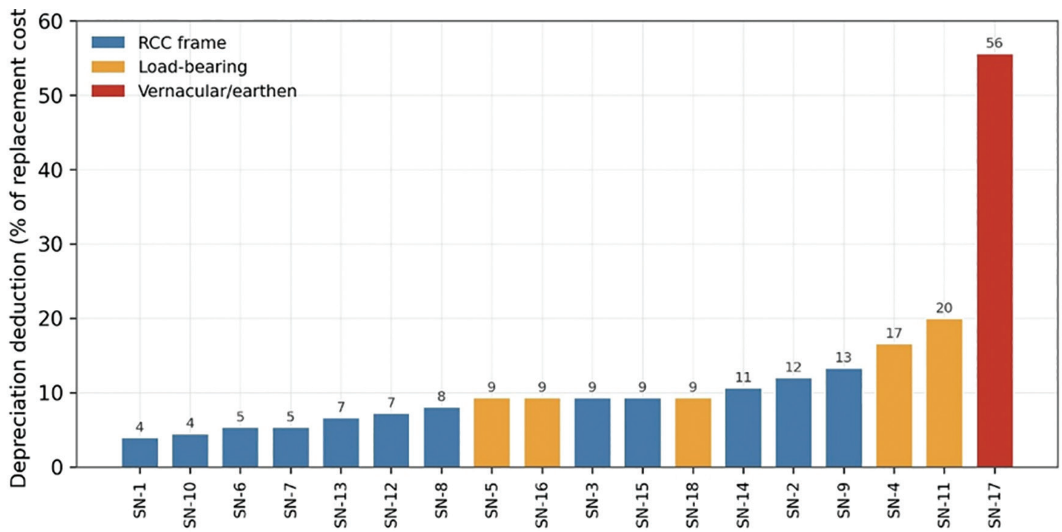

Figure 1: Depreciation deduction by dwelling, by structural typology

When depreciation is measured against the age of the primary structure alone, the relationship weakens very slightly (R^2 = 0.988). Rather than valuing a home as a single asset, this procedure breaks the building into individual materials and depreciates each separately at its own rate. The rates are 75 years for concrete frames, 50 years for UPVC, and just 10 years for earthen construction. The final compensation figure is simply the value-weighted average of these fragments. In conclusion, home is treated as a collection of depreciating materials rather than a person's shelter.

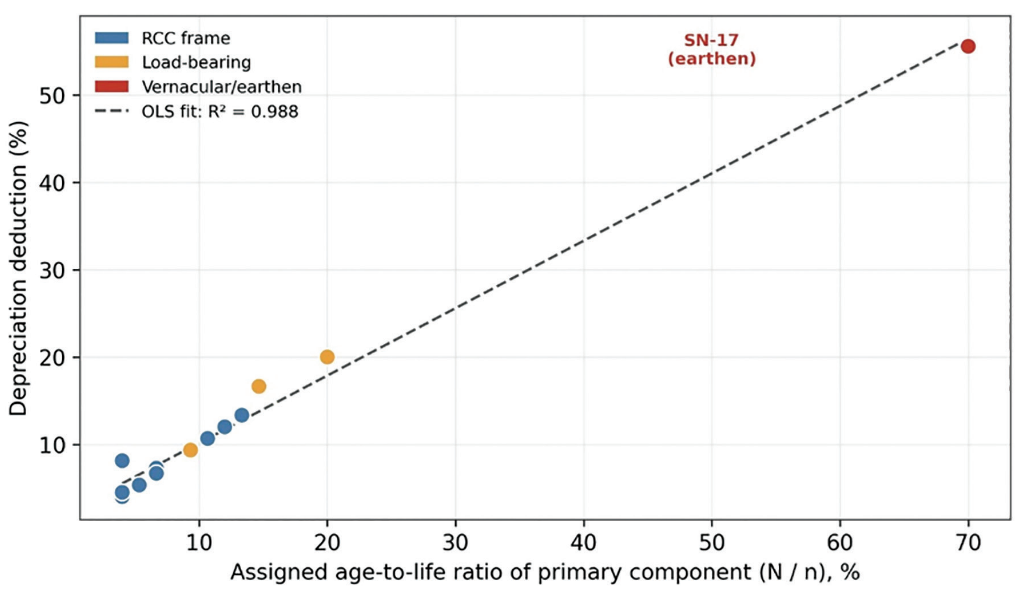

Figure 2: Depreciation deduction against the assigned age-to-life ratio of the primary component.

This approach creates complexities in compensation outcomes. Two buildings of identical age can receive unequal compensation simply because of their material mix. A small UPVC element that is depreciating at 2% per year against concrete's 1.33% is enough to pull the overall deduction upward. This could penalize the owners of mixed-material homes relative to pure concrete structures of the same age. Also, this approach can also mislead in the opposite direction. A building recorded as three years old may carry a decade-old foundation representing over 40% of its value, which makes this valuation potentially unfair.

Consequently, if the alternative construction material dominates a building's value, the penalties become severe. A CGI roof covering just over a quarter of one property's value depreciating at 22% compared to RCC frame structure which depreciates at14.7% per year. The combined depreciation rises to 16.6%. The most extreme case is a traditional earthen dwelling where earthen material accounts for 76% of value and depreciates at 10% per year, driving total depreciation to 55.6%. The owner of that home loses more than half their compensation entitlement because of the material it was built from, but he must reconstruct the house at current market rates which is unfair.

3.2. Quantification of Compensation Shortfalls and Policy Compliance

Since all 18 properties were urban sites with no transport costs considered, the full rebuilding cost and the pre-depreciation valuation are identical. This means that the compensation shortfall is exactly equal to the depreciation deducted (Table 3). In total, the 18 homeowners received NRs 41.4 million against a true replacement cost of NRs 45.8 million. The gap of NRs 4.5 million, at around 9.7% of actual rebuilding cost was ultimately passed to the affected families themselves. This is illustrated in Figure 3. On average, every homeowner was left to absorb nearly one rupee in ten of their own reconstruction cost. Since the document explicitly mentions itself as valuation guidelines and no other guidelines are available, the legal basis to claim additional compensation is very limited as well.

Table 3: Actual compensation versus full replacement cost; the shortfall equals the depreciation deduction (T=0)

SN	Structure type	Actual paid (NRs)	Full replacement cost (NRs)	Shortfall (= depreciation)	Adequacy (BV/C)
17	Load bearing + earthen	573,726	1,292,359	718,633	0.44
11	Load bearing / CGI	585,992	732,490	146,498	0.80
4	Load bearing (RCC+CGI)	901,930	1,081,891	179,961	0.83
16	Load bearing	886,062	977,274	91,212	0.91
18	Load bearing	1,120,104	1,235,409	115,305	0.91
5	Load bearing	1,687,601	1,861,324	173,724	0.91
3	RCC framed	1,241,069	1,368,826	127,757	0.91
2	RCC framed	1,350,455	1,534,608	184,153	0.88
14	RCC framed	1,814,825	2,031,520	216,695	0.89
10	RCC framed + UPVC	1,702,228	1,782,287	80,059	0.96
7	RCC framed	2,494,389	2,634,918	140,529	0.95
6	RCC framed	2,976,604	3,144,300	167,696	0.95
15	RCC framed	2,956,892	3,261,278	304,386	0.91
12	RCC + CGI	3,087,199	3,329,208	242,008	0.93
8	RCC framed + UPVC	3,380,942	3,679,703	298,761	0.92
13	RCC framed	4,604,173	4,933,042	328,869	0.93
9	RCC framed	4,656,457	5,372,835	716,378	0.87
1	RCC framed	5,369,199	5,592,916	223,717	0.96

These findings can be checked directly for compliance against international standards. Both the World Bank's ESS5 and the ADB's Safeguard Policy Statement explicitly prohibit depreciation deductions in replacement-cost compensation.

The consequences are distributed unequally. Modern concrete homes received compensation covering around 90% of true rebuilding cost, though this is also inadequate by international standards. Traditional and mixed-material structures are compensated even worse. The most extreme case is SN-17, a traditional earthen dwelling whose owner received just 44 paisa for every rupee needed to rebuild, with a deduction of NRs 718,633, or over half the property's value. Independent reconstruction under current market rates is financially impossible for that household. The procedure assessed the age of the materials and penalized the household with traditional construction heavily.

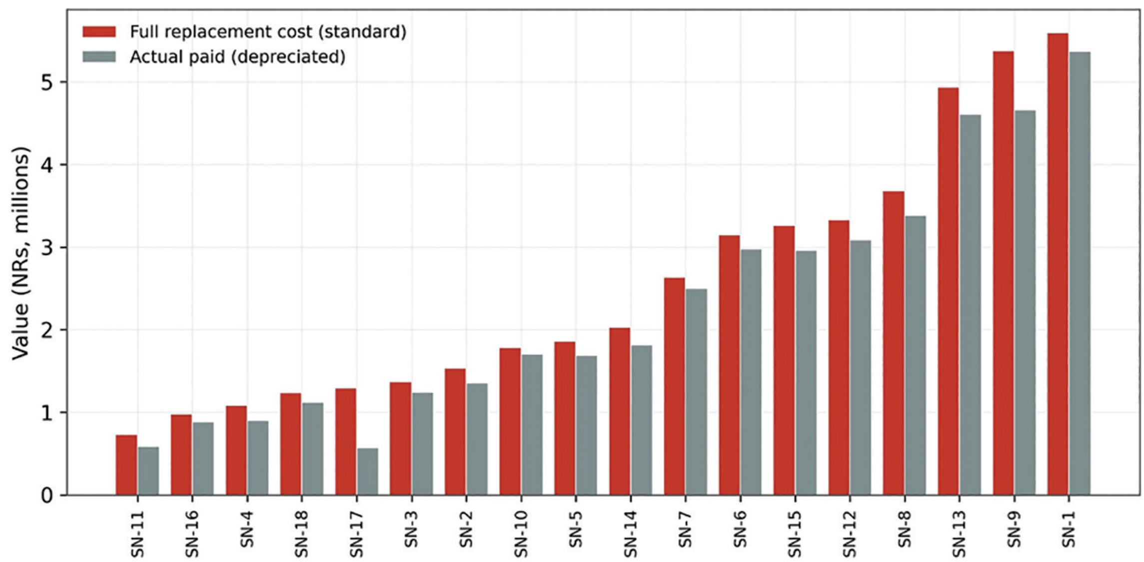

Figure 3: Actual Depreciated Value Versus Full Replacement Cost per dwelling, ordered by replacement cost.

3.3. Empirical Case analysis of Composite Structure disaggregation: Property SN-17

Property SN-17 illustrates the procedure's most extreme outcome. Two sections of a single home that were built together and seven years old are treated as fundamentally different assets under the valuation schedule. The masonry portion is assigned a 75-year life and depreciates at 1.33% per year; the earthen portion is assigned just 10 years and depreciates at 10% per year. Despite belonging to the same owner with same building and age , one half depreciates 7.5 times faster based on material type alone.

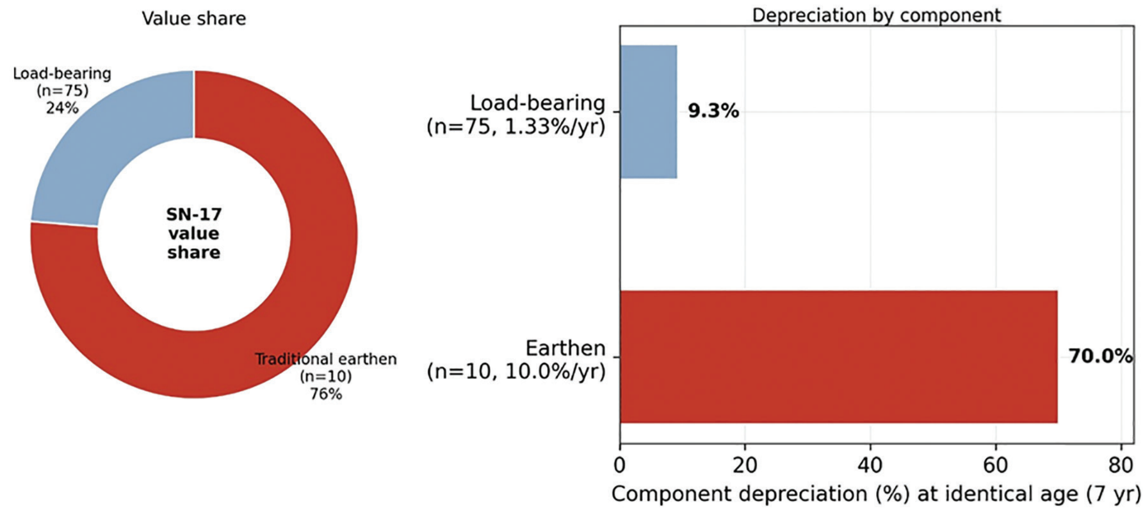

Figure 4: Figure representing component decomposition of SN-17

The earthen section accounts for 76% of the home's total replacement value. At a 10-year assigned lifespan, seven years of age translates into a 70% deduction, which is contributing to wiping out NRs 690,014 of value. The adjoining masonry wall of identical age lost just 9.3%. Together, the total deduction for SN-17 reached NRs 718,633, of which the earthen component alone generated 96%. The owner received NRs 573,726, which is just 44% of what rebuilding would cost.

If we had applied the masonry depreciation rate to the earthen section, it reduces the total deduction from NRs 718,633 to NRs 120,620 which lifts compensation to NRs 1,171,739 and restoration adequacy from 0.44 to 0.91.

3.4. Statistical Comparison of Valuation Outcomes by Construction Class

The mean adequacy ratio across the 18 sampled properties is 0.90 as shown in Figure 5. Disaggregating by service life, the long-life class (service life = 75 years; n = 12), consisting of pure RCC frames and load-bearing masonry with RCC slab, yielded a mean adequacy of 0.913, against 0.813 for the short-life class (service life < 75 years; n = 6). These include dwelling containing a CGI, UPVC or earthen component (Table 4).

A Shapiro-Wilk test rejected normality for the short-life class ($p < 0.01$), so a two-sided Mann-Whitney U test was used. The Mann-Whitney test found no significant difference between the two classes ($U = 45$, $p = 0.44$) with only a small effect size (Cliff's $\delta = 0.25$). This null result informs the absence of significant difference is explained by composition and not its class. The short-life class members (SN-8, SN-10, SN-12) are three-year-old RCC frames with minor UPVC or CGI elements. They have a smaller share of value to depress their adequacy (0.92–0.96), so they overlap the long-life class almost completely (Figure 6). Excluding only the single earthen dwelling SN-17, the short-life mean rises to 0.887 within a whisker of the long-life mean of 0.913. This indicates the apparent class gap is driven by one extreme case rather than by construction class.

The decisive factor is therefore not the presence of a short-life material but the value-weighted age-to-life ratio. Compensation penalty is severe only when a component in a structure is both old and dominant in value. This burden is concentrated in aged and earthen-dominated vernacular construction represented by SN-17 (adequacy 0.44).

Table 4: Restoration adequacy and depreciation by service-life class.

Construction class	n	Mean dep. %	Mean adequacy	Median adequacy	Adequacy range (SD)	Mean repl. cost C (NRs)
RCC frame	12	8.7	0.913	0.907	0.87–0.96 (0.03)	2,829,021
Non-RCC (load bearing, CGI, earthen)	6	18.7	0.813	0.876	0.44–0.96 (0.19)	1,982,990

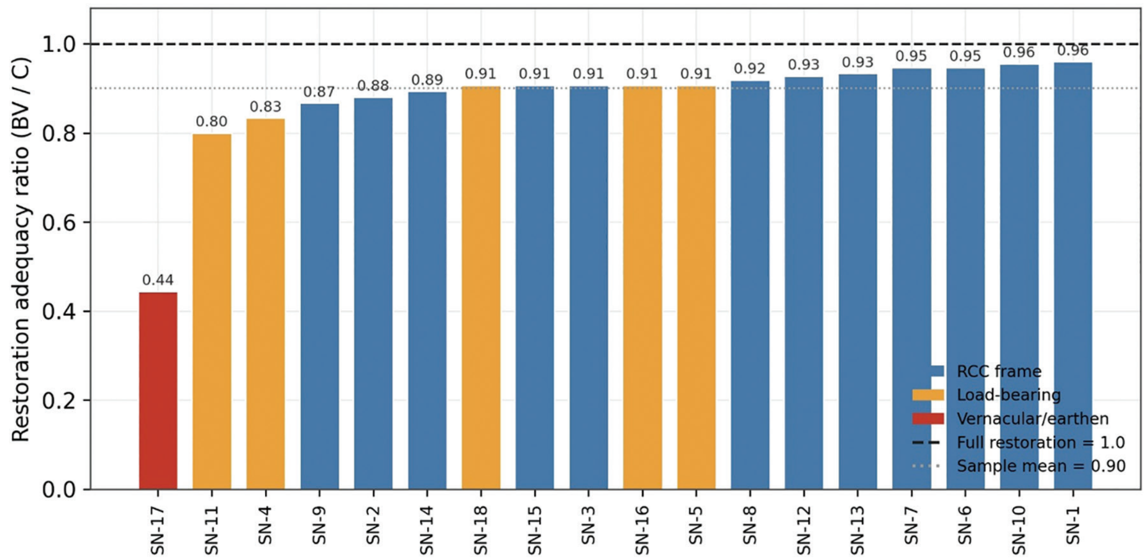

Figure 5: Graph representing restoration adequacy per house

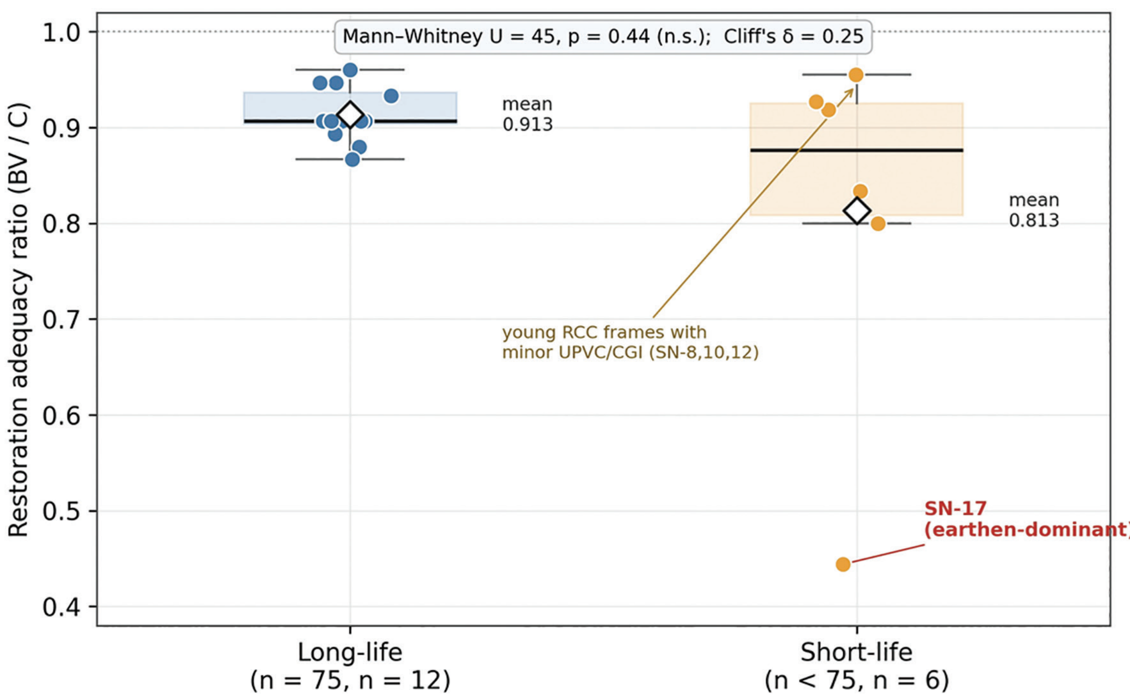

Figure 6: Restoration Adequacy by Service life class

3.5. Dual-Axis Trend Analysis: Absolute shortfall versus Proportional shortfall

An evaluation of the valuation shortfalls reveals a dual-dimensional pattern when depreciating deductions are assessed simultaneously in absolute currency terms (NRs) and as proportion of replacement value. As illustrated in Figure 7, these two dimensions operate independently across the sample based on the underlying asset size and material composition.

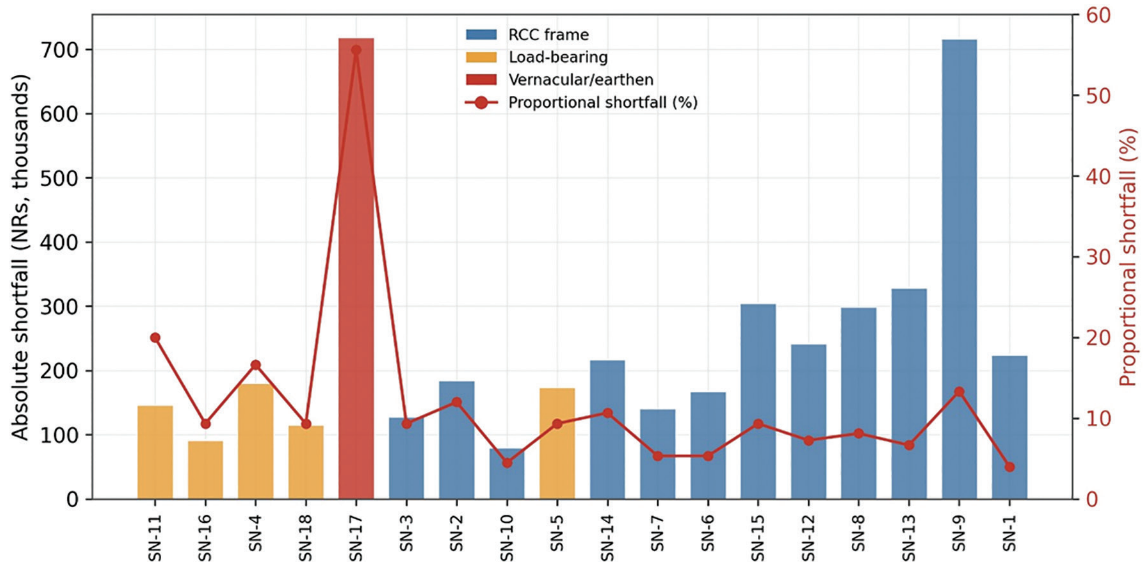

Figure 7: Dual Equity Burden: absolute shortfall (left axis) and proportional shortfall (Right axis)

In absolute rupee terms, the largest monetary losses are taken by concrete-frame homes. This is because their higher replacement values generate bigger deductions. In this case, SN-9 lost NRs 716,378 despite a relatively low building-level depreciation rate of 13.3%. But the heaviest proportional burden falls on traditional and non-concrete structures. SN-17 lost almost the same absolute amount at NRs 718,633. This represented 55.6% of its total replacement value, because its earthen material composition triggered the highest depreciation rate.

As Figure 5 illustrates, when the 18 properties are ordered by gross replacement cost along the horizontal axis, absolute shortfalls rise broadly with asset size. The proportional deduction line moves in the opposite direction and spikes precisely where low-durability materials have large value regardless of the property's overall size or worth. This implies that poorest homes lose the smallest amounts in rupees but the largest shares of what they had.

3.6. Quantitative Modeling of Policy Alternatives: Depreciation-Cap scenario

To evaluate potential regulatory alternatives to the baseline framework, a sensitivity model was constructed using a graduated depreciation cap D_{cap}. This parameter restricts the maximum allowable depreciation deduction extracted from any single structure's replacement cost. The compensation for each of the 18 properties was systematically recomputed using this function:

$$C.(1 - \min(D, D_{cap})$$

where D represents the property's empirical depreciation fraction under current rules. The resulting financial outcomes and material specific impacts in restoration across these variations are recorded in Table 5.

Table 5: Depreciation-cap policy scenarios across all 18 dwellings: aggregate cost versus per-typology equity.

Policy option	Aggregate paid (NRs)	Aggregate shortfall (NRs)	Shortfall (% of C)	RCC / LB mean adequacy	Earthen (SN-17) adequacy
Actual (no cap)	41,389,846	4,456,341	9.7	0.92 / 0.87	0.44
D ≤ 0.50	41,462,300	4,383,888	9.6	0.92 / 0.87	0.50
D ≤ 0.30	41,720,772	4,125,416	9.0	0.92 / 0.87	0.70
D ≤ 0.25	41,785,390	4,060,798	8.9	0.92 / 0.87	0.75
D ≤ 0.20	41,850,008	3,996,180	8.7	0.92 / 0.87	**0.80**
D ≤ 0.10	42,347,595	3,498,593	7.6	0.93 / 0.90	0.90
D = 0 (full replacement cost)	45,846,188	0	0.0	1.00 / 1.00	**1.00**

The simulations reveal two distinct mathematical characteristics. First, depreciation cap operates as a highly localized structural correction due to the specific clustering of the dataset. Because the calculated depreciation of the RCC frame and standard load-bearing masonry properties rarely exceeds 20%, imposing this cap of $D_{cap} \leq 0.2$ leaves their mean adequacy ratios essentially unchanged at 0.92 and 0.87 respectively (Table 5). However, this specific threshold substantially improves the compensation of heavily depreciated vernacular structure (SN-17), raising its adequacy ratio up from 0.44 to 0.80. This significant mitigation is achieved at a nominal cost to the project.

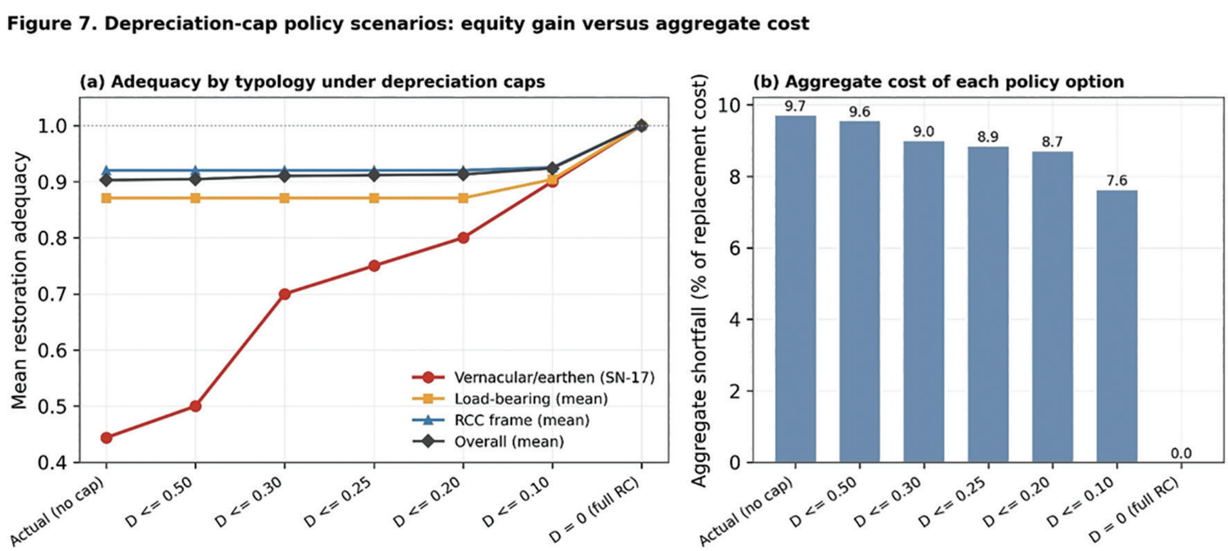

Figure 8: Depreciation cap policy scenarios

Second, the simulation demonstrates that shifting to a absolute new-build replacement standard ($D_{cap} = 0$) eliminates the entire structural funding gap across all properties. As per Figure 8, tightening the cap down to zero establishes a predictable fiscal ceiling requiring a total additional funding allocation of exactly NRs 4,456,341 to achieve an adequacy ratio of 1.00 across all structural typologies. The curves in Figure 8 (a) illustrate how the vernacular house experiences a steep linear increase in adequacy as D_{cap} decreases, while the modern RCC and masonry houses remain largely horizontal until their low baseline depreciation thresholds.

3.7. Extended Projection Modeling: Omitted Non-Structural Resettlement Entitlements

While the analysis focuses strictly on structural asset values, achieving full replacement cost under international safeguard frameworks (World Bank ESS5 and ADB ESF) requires accounting for other transaction and transitional costs. As per Table 6, these standard international line items comprise of material transport costs, registration fees, relocation allowances, and income lost during restoration.

Table 6: Full replacement-cost entitlements with documented benchmarks from comparable donor-financed RAPs.

Entitlement	Policy basis	Documented regional benchmark	References
Transaction costs	Registration/title fees, transport of materials to site (ADB SPS; ESS5 GN5, 2018)	Reimbursed on documented receipts; no fixed % in policy. SASEC Nepal Highway RP (ADB 52097-001, 2018) includes registration and material-transport costs in replacement cost.	(Asian Development, 2018)
Transitional housing	Support for the reasonable reconstruction period (OP 4.12 para. 6(c)(i))	Prevailing local rent × duration: 3 months partial, 6 months major, 9–12 months full reconstruction. Dhaka-Sylhet Highway RP (ADB 53382-001, 2021): BDT 50,000 for 3 months.	(Asian Development, 2021)
Shifting/ moving allowance	Cover actual moving costs (OP 4.12)	Flat per-household lump sum from local survey, or daily wage × 90 days. Tanahu Hydropower (ADB 43281-013, 2018): 90-day allowance at the local wage rate.	(Asian Development et al., 2018)
Income loss in transition	Restore pre-displacement income (ESS5)	Daily/monthly income × disruption period; poverty-line floor for below-poverty-line households (Assam Roads RP, ADB 42265-023, 2016: INR 18,000 over 6 months).	(Asian Development, 2016)
Vulnerable top-up	Special measures for the poor and vulnerable (ESS5; ADB SPS)	One-time grant on top of standard entitlements. Tanahu Hydropower (ADB 43281-013): NRs 55,000 per vulnerable household, paid and documented in the project's monitoring report.	(Asian Development et al., 2018)

None of these additional entitlements are captured under Nepal's building valuation procedure. To estimate the approximate magnitude, conservative regional benchmarks drawn from published donor-financed Resettlement Action Plans (RAPs) across South Asia are applied to the 18 households. Table 7 represents these additional entitlements. The transitional, shifting, and vulnerability figures are explicitly indicative. The precise values would require local rent and wage data and a household vulnerability survey that fall outside the scope of this study. However, they are sufficient to establish that the non-structural entitlement gap is of the same order as the depreciation deduction itself.

Table 7: Illustrative full replacement-cost entitlement for the 18 affected households.

Component	Amount (NRs)	Basis
Compensation actually paid (depreciated)	41,389,846	*Compensation record total (exact)*
+ Depreciation deduction restored	4,456,341	*Exact: C − BV*
= Undepreciated structure cost (C)	**45,846,188**	*BCVP gross value (exact)*
+ Transitional housing	≈ 2,430,000	*Illustrative: 18 × 9 months × ~NRs 15,000/month (full reconstruction)*
+ Shifting/moving allowance	≈ 720,000	*Illustrative: 18 × ~NRs 40,000 flat (regional benchmark)*
+ Vulnerable-household top-up	≈ 330,000	*Illustrative: 6 vulnerable HHs × NRs 55,000 (Tanahu benchmark)*
+ Transaction costs; income-loss restoration	not quantified	*Documented per household; requires receipts and income survey*
≈ Full replacement-cost entitlement (excluding last row)	**≈ 49,326,000**	*Illustrative lower bound*

Table 7 reveals that the depreciation deduction is constitutes only the first layer of compensation shortfall. The non-structural components including transitional housing, shifting allowances and vulnerability support, are of comparable magnitude to the depreciation gap itself. Restoring the depreciation deduction brings the aggregate entitlement baseline to NRs 45.8 million.

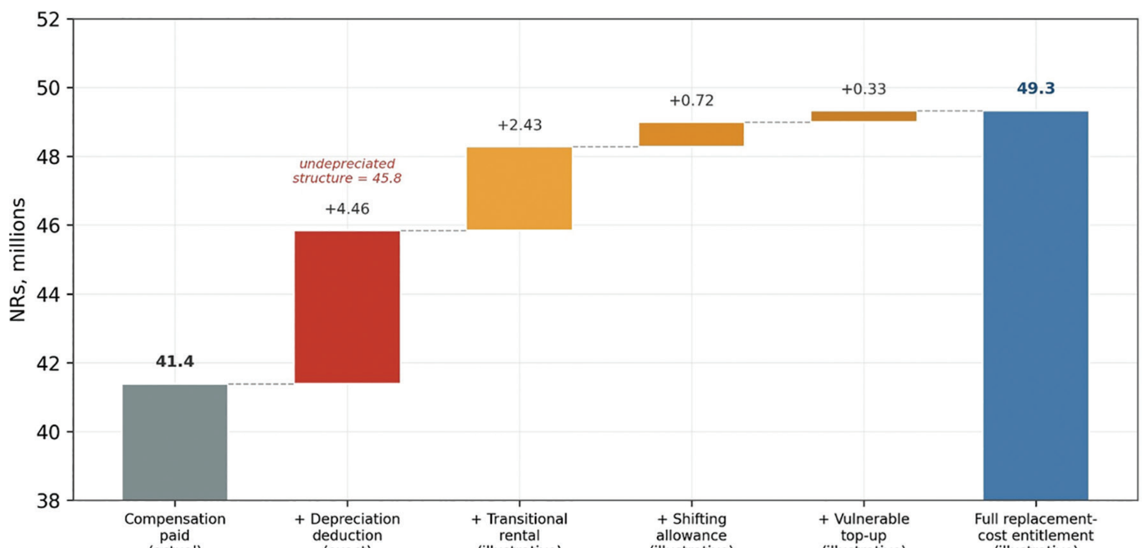

Figure 9: Figure representing the other costs added to compensation paid

4. Discussion

4.1. Why Depreciated Replacement Cost is Inappropriate for Construction Induced Damage?

Depreciated replacement cost is a widely recognized method in accounting which is commonly used for corporate asset valuation, taxation purposes. It is appropriate in contexts where the reduction in book value with respect to age of property is both analytically and legally appropriate. However, applying the same method to calculate compensation for structural damage caused by construction activities could represent a mismatch of this framework. When blasting activities due to construction damages a primary residence in government projects, the legal and ethical remedy is to provide restoration or full reconstruction costs. Since construction materials, masonry components, and engineering labor can only be procured at prevailing market prices, the actual cost of repair or rebuilding is entirely independent of the building's chronological age (Ren et al., 2024). This is a principle explicitly recognized by both the World Bank's ESS5 and the Asian Development Bank's Safeguard Policy Statement. These document mandates the replacement-cost valuation without any deduction for depreciation.

Any administrative deduction of depreciation effectively transfers a measure share of the project's liability directly onto the affected household. The structure of Nepal's Building Valuation Procedure 2070 exposes this precisely. The gross value **C** accurately reflects the full current cost of reconstructing the property at today's market rates. Yet when the depreciation modifier $(1 - D)$ is applied, it implies that the government's obligation to restore the structure decreases proportionally with the building's age-to-life ratio (N/n). This proposition has no basis in engineering context because the owner must rebuild the house at the current market rates. The cost of repairing a crack in a seven-year-old earthen wall is identical to repairing the same crack in a newly built one. Treating damage compensation in relation to depreciation therefore transforms a public liability which undervalues private property, which makes the full physical rehabilitation financially impossible. Apparently, it also falls hardest on owners of vernacular construction who are least able to absorb the shortfall.

4.2. Depreciation Based Compensation Disadvantages Vulnerable Households and Violates International Standards

Nepal's Building Valuation Procedure, 2070 uses straight-line depreciation to determine compensation for permanent damage due to construction activities. This may be appropriate for regular asset taxation methods, but it is inappropriate when applied to determining compensation. The forces due to blasting in construction travel through a structure regardless of its age or material type. The cost of repairing or a crack in an old earthen wall would be similar from repairing the same crack in a newer house. Yet the formula reduces the government's financial obligation as the building ages, through the depreciation modifier $(1 - D)$, which decreases proportionally with the age-to-life ratio (N/n). This has no basis in engineering reconstruction.

The procedure assigns service lives of 75 years to RCC frames, 50 years to CGI and UPVC elements, and only 10 years to earthen construction. While these service life classifications reflect materials wear out over time, applying them to damage compensation creates an penalizes households living in vernacular structures. In the most affected property, SN-17, depreciation erased 70.0% of the earthen component's value as compared to just 4.0–13.3% for modern concrete structures. Since vernacular structures like mud-bonded and earthen construction represents the primary categories of houses of low-income households in Nepal this penalty seems unfair. Broader research confirms that unfair compensation packages are a major structural cause of poverty after the relocation (Otsuki, 2024). The distortion does not affect all vernacular structures equally as it affects the most where short-life materials dominate a property value and the structure is already old rather than applying uniformly across construction classes. This pattern is consistent with evidence across other countries that statutory valuation methods underestimate the cost of establishing the displaced households and that the more vulnerable and marginal these communities are, the greater their loss of livelihood will the owners have to bear the disadvantage (De Maria et al., 2023). Studies in compensation measures have further revealed that lack of fair and appropriate compensation resulted in lack of food security as well as social and family disintegration (Dires et al., 2021).

Nepal sits in one of the most active seismic active zones, and the inadequate compensation frameworks leaves affected families without the resources to rebuild to safer engineering standards (Bothara et al., 2022). Therefore, these consequences of these actions have larger impact apart from financial loss. This shortfall can force households to reconstruct using the same non-engineered method which directly undermines Nepal's national building codes. However, a recent study in remote districts of Nepal demonstrates that appropriate and locally sourced construction can rebuild structures to engineering standards at a modest cost (Bothara et al., 2024). The reconstruction is possible for low-cost housings if compensation fully fund the total replacement cost rather than a depreciated book value.

Table 8: The replacement-cost principle versus local practice (Building Valuation Procedure, 2070).

Dimension	International principle (WB ESS5; ADB SPS / ESF)	Local practice (Building Valuation Procedure, 2070)
Compensation basis	Full replacement cost of equivalent structure	Depreciated replacement (book) value
Depreciation	Explicitly excluded for structures	Deducted: typology rate × age
Rate tiers	Not applicable (depreciation prohibited)	1.33%/yr RCC (n=75); 2.00%/yr CGI/UPVC (n=50); 10.00%/yr earthen (n=10)
Stated principle	Replacement cost without depreciation or reductions	$V = [(B \cdot Co + T)(1-D)] \cdot A + O$, with $(1-D) < 1$
Substandard / vulnerable	Must fund a safe equivalent; special measures for poor	Shortest tiers → largest deductions on poorest construction
Domestic-law shortfall	Top-up required to reach replacement cost	No top-up mechanism in the procedure

As per the table 8, the misalignment between local practice and international standards raises a serious question: what asset value is the project obligated to restore? World Bank ESS5 and the updated ADB Environmental and Social Framework (Zhang et al., 2023) both require that structural compensation fund a safe, contemporary equivalent without any reduction for age or depreciation. However, Nepal's Building Valuation Procedure, 2070 applies a depreciated book value instead. Also, these international frameworks further require that where domestic law falls short of full replacement cost, top-up mechanisms must bridge the gap where the replacement cost is inadequate. However, no such mechanism exists within the local procedure which implies that the shortfall is structurally built into the compensation formula. This also formalizes a documented failure in compliance to international practice.

4.3. Total Rehabilitation Mechanism Requires a Legislative Reform

The 9.7% structural depreciation shortfall is the minimum boundary of the rehabilitation gap. As shown in Figure 8, the depreciation deduction of NRs 4,456,341 accounts for only approximately 56% of the total unaddressed shortfall against international standards. The remaining 44% comprises entitlements these procedure does not recognize. These includes transitional housing costs, shifting allowances, and vulnerability support which are documented through regional pricings. Addressing depreciation schedules alone therefore cannot represent the true economic burden on affected households. Literature also suggests that Successful resettlement requires pre- and post-relocation actions that will help everyone develop new routine, economic arrangements and improve their well-being (Downing et al., 2021).

When blasting damage makes a home uninhabitable, the owner faces immediate cash demands from his pocket like local rents during reconstruction, material transport premiums, and managing household disruption without any institutional support. These are concerns documented under both World Bank ESS5 and the ADB Safeguard Policy Statement. Without incorporating these benchmarks into domestic compensation practice, the framework leaves a structural barrier that makes genuine physical and economic rehabilitation financially impossible for households within the project impact zone. Not only fair compensation is necessary but an appropriate guidance from government to use the limited compensation amount for resettlement is necessary(Dires et al., 2021).

The compliance gaps documented in this study arise from a legislative void within Nepal's policy on compensation valuation. While the Land Acquisition Act, 2034 (1977) provides the statutory mandate for the project's Compensation Determination Committees (CDCs), it completely lacks a technical methodology for evaluating construction-induced structural damage to primary residences. To address this, the state relies on the general Building Valuation Procedure (BCVP) which was originally created for real estate taxation purpose.

No domestic law in Nepal currently mandates a zero-depreciation replacement standard, any form of stipends during transition phase, or vulnerability entitlements for households whose houses are compromised by public works. The Government of Nepal routinely agrees and executes these rigorous standards within project-specific international donor agreements under World Bank ESS5 and the ADB Safeguard Policy Statement. Yet, Nepal has not included these laws in the domestic practice. As a result, the compensation which the affected household receives depends on which financial institution happened to fund the project that damaged their home.

Therofore a targeted reform is necessary through instruments like the Ministry of Urban Development. It can amend the operational guidelines of the Building Valuation Procedure, 2070 specifically for public works where damage is induced by construction activities. Legally inserting a parametric depreciation cap of $D \leq 0.20$ or eliminating the $(1 - D)$ multiplier entirely for damaged primary residences would immediately align domestic compensation practice with international standards. The reform is a change in an administrative procedure, and it is evident from the scenario simulations that it is can be executed at a fiscally manageable cost.

5. Conclusion

The compensation paid for 18 houses that were damaged during the construction of the infrastructure project was calculated using an open and transparent process by the team of experts. However, compensation method based on depreciated replacement cost according to the Nepal Building Valuation Procedure 2070, led to a result that could be influenced only by two administrative factors which is the assessed age of the building and its estimated useful life. The deduction of depreciation varied from 4.0% of the value of the newest reinforced concrete house to 55.6% of the value of the seven-year-old earthen house. The percentage of depreciation is calculated to be a perfect identity function ($R^2 = 1.00$) with respect to the age-life ratio.

In total, the 18 affected households received NRs 41.39 million, against a true replacement value of NRs 45.85 million with a shortfall of NRs 4.46 million or 9.7% of the total rebuilding cost. Since all the sites were urban the transportation cost did not factor into valuation as well. In this regard, the ESS5 guideline of the World Bank and the Safeguard Policy Statement of the Asian Development Bank do not include depreciation in replacement cost compensations. In concern to this aspect Nepal's national policy does not conform to international best practices accepted by the Government of Nepal in funded projects. The 9.7%

shortfall in compensation only reflects the minimum possible deficit due to depreciation. Using conservative estimates for entitlements of transitional accommodation, shifting and vulnerability allowances, employment lost further lifts the total entitlement benchmark up to around NRs 49.3 million. If we consider these figures from practices from other funded projects the depreciation accounts for about 56%.

The scenario analysis conducted in this study recommends a clear solution to this problem at a manageable cost to the government. Introducing a depreciation cap of $D \leq 0.20$ would leave the mean reconstruction adequacy of RCC and load-bearing houses largely unchanged, since their depreciation rarely exceeds this threshold to begin with (remaining at 0.92 and 0.87 respectively). At the same time, it would raise the adequacy of the most severely affected property. In our study the house number SN-17, the construction adequacy raised from 0.44 to 0.80, which is a substantial improvement achieved. Also, the overall shortfall percentage is decreased from 9.7% to 8.7%. A complete shift to a standard with zero depreciation would close this gap entirely at a cost that can be quantified.

These findings point towards the necessity of policy reform. Nepal's Land Acquisition Act, 2034 provides no methodology for valuing structural damage due to construction activities. This leaves the Building Valuation Procedure, 2070 to fill this gap by default. The problem is that this procedure was originally designed for taxation and insurance purposes where depreciation is appropriate and not for situations involving damage caused by public infrastructure projects. A simple but targeted reform is necessary by capping the depreciation at $D \leq 0.20$ or removing it entirely for severely damaged houses which require full reconstruction. This change would standardize Nepal's compensation practice with level to zero-depreciation standard that is internationally recognized.

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7. Annex 1

SN	Component material	Area (ft²)	BCVP life n (yr)	Age N (yr)	Annual rate (%/yr)	Repl. cost C (NRs)	Book value BV (NRs)	Comp. dep. %	Value share %	FY
4	RCC frame (cement masonry)	365.14	75	11	1.33	791,654	675,544	14.7	73.2	2070
	CGI roof / enclosure	161.46	50	11	2.00	290,237	226,386	22.0	26.8	2070
8	Ground-floor RCC frame	635.92	75	10	1.33	1,521,721	1,318,825	13.3	41.4	2071
	Upper-floor RCC frame	635.92	75	3	1.33	1,680,724	1,613,495	4.0	45.7	2078
	Upper-floor UPVC enclosure	265.50	50	3	2.00	477,257	448,622	6.0	13.0	2078
10	RCC frame	508.49	75	3	1.33	1,343,929	1,290,172	4.0	75.4	2078
	UPVC enclosure	243.86	50	3	2.00	438,357	412,056	6.0	24.6	2078
11	CGI / UPVC (single material)	374.00	50	10	2.00	732,490	585,992	20.0	100.0	2071
12	RCC frame	1,068.92	75	5	1.33	2,727,371	2,545,546	6.7	81.9	2076
	UPVC roofing / enclosure	303.82	50	5	2.00	601,837	541,653	10.0	18.1	2076
17	Load-bearing (stone/brick in mud)	201.83	75	7	1.33	306,624	278,006	9.3	23.7	2074
	Traditional earthen home	428.00	10	7	10.00	985,735	295,721	70.0	76.3	2074

BCVP rate tiers: RCC frame / load bearing (n = 75 yr) → 1.33%/yr • CGI / UPVC enclosure (n = 50 yr) → 2.00%/yr • traditional earthen (n = 10 yr) → 10.00%/yr. Component dep. % = N ÷ n; the building-level deduction is the value-weighted mean.