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Stolen Strata: Brick Kilns and the Loss of Karewa Tableland in Budgam, Kashmir, 1993–2025, with a Correction to an Earlier Estimate

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Version	Version 2, October 2026
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This version replaces my EarthArXiv preprint of 4 September 2026. The main numbers of that version (a rise in bare-earth share from 1.84% to 8.43% and a net increase of 190.3 ha) are withdrawn; Section 4.1 of this paper shows why.

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Abstract

Karewa tablelands are the flat-topped, scarp-bounded remnants of the old lake and river deposits of the Kashmir Valley. Reporting from Kashmir has said for years that they are being dug away for brick clay and fill, but I did not find a satellite measurement of how much, where and when. This study asks three questions: how much karewa tableland that was vegetated in 2013–2015 is no longer vegetated in 2023–2025; what that land has become, in particular how much of it now lies inside brick-kiln fields; and where and when the change happened. I map 180 scarp-bounded tablelands (173.3 km^2) in a 2,160 km^2 box across Budgam, Pulwama and Srinagar districts from the Copernicus elevation model, using slope, height above drainage and the share of each flat top's edge that is a scarp. I then follow the yearly peak NDVI of every 30 m pixel in Landsat 8/9 alone and flag land that was clearly vegetated in 2013–2015 and is not in 2023–2025, with a strict and a looser test. They flag 107 ha and 329 ha of the tablelands. Two stratified random samples, 240 points in all, labelled blind to stratum against recent imagery, show that about 299 ha (90%) of the flagged land is not vegetated today and that about 262 ha of it was vegetated in imagery of 2013–2015. Under a written rule for where a kiln field ends, applied afterwards to the edge points of both samples (this relabelling was not blind to stratum), about 210 ha (95% interval roughly 189–231 ha) lies inside brick-kiln fields, 197 ha of it on land that the older imagery also shows as vegetated. The change is concentrated in two kiln belts in Budgam. At Rangeen Kultreh a kiln field opens after 2016 on land that was vegetated in every usable year since 1993 but one anomalous year, and a pollution-control filing before the National Green Tribunal independently dates a kiln there to 2017. On the Bandagam–Batapora tablelands land with little vegetation was already present in the 1990s, and the looser test finds more post-2013 loss there than at Rangeen Kultreh. Outside these two belts the tablelands convert at the same rate as comparable flat, raised land. I could not measure how deep the ground was dug, and I found no conversion of this kind on the saffron tablelands of Pampore. An earlier version of this work reported that the bare-earth share of karewa terraces rose from 1.84% in 1994 to 8.43% in 2025. Section 4.1 shows that the rise came from comparing Landsat with a differently built Sentinel-2 product (on Landsat alone the 2025 figure is 0.07%), and it is withdrawn.

Keywords: karewa, Kashmir Valley, brick kilns, land conversion, Landsat time series, sensor consistency, accuracy assessment

1. Introduction

Karewas are the raised, flat-topped plateaus that stand above the floor of the Kashmir Valley. They are made of lake and river sediments laid down over the last few million years and capped with loess, and they carry

orchards, saffron and dry-land crops. They are also a convenient source of clay. Journalists and activists in Kashmir have reported for years that karewas are being cut for brick kilns, for railway and road embankments, and for building plots (Rafi and Syed, 2023; Bhat, 2021).

That is what the reporting says. What I could not find was a measurement: how many hectares, in which places, starting when, taken from satellite data and not from testimony. The first version of this study tried to supply one and got it wrong. It reported that bare ground on karewa terraces had more than quadrupled since 1994, with almost all of the rise after 2015, and it built a saffron value-at-risk figure on top of that. The rise coincided exactly with the point where the analysis switched from Landsat to Sentinel-2 imagery. I had noted that as a limitation, but it accounted for the whole rise.

This paper asks three questions about the scarp-bounded karewa tablelands of central Kashmir:

- **RQ1.** How much tableland that was vegetated in 2013–2015 was no longer vegetated in 2023–2025, and does it convert faster than comparable flat, raised land? (Sections 4.3 and 4.4)
- **RQ2.** What did that land become, and in particular how much of it now lies inside brick-kiln fields? (Section 4.5)
- **RQ3.** Where and when did the change happen? (Section 4.6)

Every comparison through time is made inside one sensor family, on a terrace map checked against a published geological map. Section 4.1 first shows why the headline of the earlier version was wrong. Sections 4.7 and 4.8 report two questions the data could not support: a link to the saffron land and the depth of excavation.

The study gives a dated, mapped and sample-validated estimate of vegetated karewa tableland now inside brick-kiln fields. It also documents a cross-product NDVI comparison that produced a fourfold rise, with the single-sensor check that removes it, and a terrain rule (height above drainage plus scarp share) that separates scarp-bounded tablelands from fans and aprons.

I use "karewa tableland" and "terrace" for the scarp-bounded flat tops this study maps. That is a narrower thing than the whole Karewa Group outcrop, and Section 3.2 and Section 6 say how much narrower.

2. Background

2.1 The karewa landscape

De Terra and Paterson (1939) set out the first systematic stratigraphy of the Karewa deposits as a lake-to-river infill tied to the uplift of the Pir Panjal. Dar and Zeeden (2020) review the loess and palaeosol sequences that cap the karewa surfaces and their value as a Quaternary climate archive, and their Figure 2, after Bhatt (1982), maps where the Karewa formations lie across the valley. Bhat et al. (2016) describe earthquake-related deformation structures in the same sediments. The surface being removed is therefore both farmland and a geological record.

2.2 Brick kilns in Budgam

Budgam district holds most of Kashmir's brick kilns. A feature in Kashmir Life (2019) puts the share at 60 per cent and describes an industry that was mostly confined to the Jhelum belt until the late 1960s and had hundreds of chimneys in Budgam by the mid-1970s. The Jammu and Kashmir Pollution Control Committee reported 213 kilns in the district in April 2023, with 96 notices for lapsed consent and 46 closure orders (JKPCC, 2023a). Its status report of October 2023 lists 226 kilns by name and village: 100 with consent, 11 with

applications under process, 43 under closure orders and 72 under legal notice (JKPCC, 2023b). At Rangeen Kultreh in Chadoora tehsil, press reports describe about two dozen kilns on karewa land, the felling of about a thousand almond trees for new ones, and a complaint by the Air Force Station at Srinagar that kilns around it had multiplied over the previous decade (Bhat, 2023; Kashmir Despatch, 2023; Business Standard, 2023). A committee report filed before the National Green Tribunal in a case brought by one kiln at Rangeen states that the kiln was commissioned in 2017 without consent, was ordered closed in September 2018, and has 20 other kilns within one kilometre (JKPCC, 2024).

2.3 Saffron

The saffron belt at Pampore is the best known use of karewa land. Official figures reported in the press put the cultivated area at 3,715 ha, stable since 2010–11 after a fall from 5,707 ha (Kashmir Reader, 2026), with production of 19.58 t in 2024–25 (Kashmir Reader, 2026; Greater Kashmir, 2026); FAO GIAHS (2012) describes the system. The earlier version of this paper tied its degradation estimate to saffron value. Section 4.7 explains why this version does not.

2.4 Measuring change across sensors

Long satellite records are stitched from different instruments. Landsat 5 and 7 carry similar sensors; Landsat 8 and 9 carry a different one with narrower bands, and Roy et al. (2016) give the adjustment between them. Sentinel-2 differs again in band placement, pixel size and processing. A fixed NDVI threshold applied across such a join can register a change that is only the instrument changing. Section 4.1 is a case of exactly that.

2.5 Satellite studies of brick kilns and of land change

Brick kilns have been mapped from space before, but as objects to be counted, not as land conversion through time. Boyd et al. (2018) counted kilns across the South Asian "Brick Belt" from sampled high-resolution imagery, and Lee et al. (2021) trained a deep-learning detector to find kilns in Bangladesh and check them against siting rules. Those studies say where kilns are; they do not say what land a kiln field replaced or when. General Landsat time-series methods such as LandTrendr (Kennedy et al., 2010) and CCDC (Zhu and Woodcock, 2014) detect such change pixel by pixel, and Olofsson et al. (2014) set out how to turn a change map into an area estimate with a reference sample. This study uses simpler window tests than those frameworks, because the record here is thin before 2013, and follows Olofsson et al. for the area estimate. I did not find a satellite study of land-use change on the karewas themselves.

3. Data and Methods

Everything is scripted. Satellite composites were exported from Google Earth Engine (Gorelick et al., 2017) and analysed locally in Python. The scripts, tables and maps are in the `v2_redesign` folder of the project repository; the large rasters are regenerated by the export scripts and are not stored in the repository.

3.1 Study area

The study box runs from 74.55° to 75.15° E and from 33.80° to 34.15° N, about 2,160 km^2, covering the karewa tablelands of Budgam, the Pampore–Lethpora tablelands, and parts of Pulwama and Srinagar districts. The first analysis used a smaller box (74.75°–75.15° E, 33.85°–34.15° N) drawn around Pampore. It was widened westward once it became clear that the change was in Budgam.

3.2 Terrace delineation

The earlier version selected cells with a high topographic position index and a slope under 8°. That rule picks out rims and spurs, and it left the flat plateau interiors out; my own field photographs at Lethpora, taken on a saffron tableland, fell outside every polygon it produced. The new rule looks for the flat top itself and then asks whether it is bounded by scarps.

From the Copernicus GLO-30 elevation model (acquired 2011–2015), reprojected to UTM 43N with a buffer of about 10 km around the box, I compute slope on a lightly smoothed surface and height above the nearest drainage, HAND (Rennó et al., 2008), with drainage lines defined by a contributing area of 3 km². A cell is a candidate if its slope is under 4°, its HAND is over 15 m and its elevation is under 1,950 m. Candidates are cleaned with a 2-pixel opening and grouped into connected flat tops of at least 0.05 km². For each flat top I measure the share of a 3-pixel ring just outside it that is steeper than 6°. This scarp share separates a tableland, which drops away on most sides, from an alluvial fan or a valley-side apron, which is flat and raised but slopes gently into its surroundings.

The scarp-share cut-off was set from independent evidence, not by eye. In the original box I georeferenced the Karewa Group map of Dar and Zeeden (2020, Figure 2) and measured, for each flat top large enough for that map to resolve, how much of it lies on Karewa formations. At a scarp share of 0.25 or more, 90% of those flat tops are on Karewa formations (18 of 20); at 0.20 the figure falls to 79% (19 of 24). The cut-off is therefore 0.25. That comparison rests on few flat tops, and because the same map is used in Section 4.2 to report agreement, the agreement reported there is not a fully independent test of the cut-off. Five small flat tops that pass the rule but look like foothill aprons or valley floors inside the mountains (1.9 km² together in the original box; the matching flat tops in the wide box come to 1.2 km², under 1% of the terrace area) were removed after a first-pass review of terrain and satellite imagery; I have not yet confirmed those labels myself. Nothing reported here depends on them: inside the box the removed flat tops cover 0.5 km² and hold 0.09 ha of strict-test conversion and none by the drop test. They are listed with reasons in the repository.

The same rule, unchanged, was then run on the wide box.

3.3 Satellite time series

For every year from 1990 to 2025 I took all Landsat 5, 7, 8 and 9 Collection 2 Level 2 surface-reflectance scenes over the box, masked cloud, dilated cloud, shadow and snow with the pixel-quality band, and computed NDVI. For each pixel and year I kept the 90th percentile of NDVI over the whole year. The yearly peak is the useful quantity here: a field that is bare in winter or at harvest still has a high peak, while ground that has been stripped stays low all year. Three series were built:

- Landsat 5, 7, 8 and 9 together, with Landsat 8 and 9 red and near-infrared passed through the linear transformation of Roy et al. (2016), for the long view. The coefficients are those Roy et al. give for converting Landsat 8 reflectance to Landsat 7 (OLI to ETM+, ordinary least squares). The first run of the long series used their Landsat 7-to-8 coefficients on Landsat 8/9 data, that is, in the reverse direction; it was re-exported with the right coefficients in October 2026 (`gee_05_long_series_fixed.js`), and all long-view figures in Section 4.6 and Figure 4 come from the corrected run. The check of the earlier estimate in Section 4.1 uses the original-box series, which has not yet been re-exported. The conversion tests never used this adjustment;
- Landsat 8 and 9 alone, unadjusted, 2013–2025, which is the series the conversion tests use;
- Landsat 7 alone, 2013–2021, as an independent check on the Landsat 8 result.

A Sentinel-2 series for 2019–2025, cloud-masked with Cloud Score+ (Pasquarella et al., 2023) and exported at 30 m (nearest-neighbour resampling of the 10 m pixels), serves as a third instrument. Because it starts in 2019

it can confirm the end state of a detection, not the vegetated start. I also exported the number of clear observations per pixel per year, counted over all Landsat sensors. A year is used only if the median terrace pixel has at least 10 clear observations. That removes 1990, 1991, 1992, 1995, 1996 and 1997. Landsat 9 adds observations from 2022, so the late window of the Landsat 8/9 series rests on more scenes than the early one (median 65, 58 and 38 clear observations from all Landsat sensors in 2023–2025, against 42, 32 and 37 in 2013–2015). A 90th percentile taken over more scenes tends to be higher, which works against detecting loss.

For the check on the earlier estimate I also exported the June–September median NDVI, which is what the earlier version used.

3.4 Conversion tests

All tests compare two three-year windows inside one series, so that a single dry or cloudy year cannot create or remove a detection.

Strict test. A pixel is converted if its yearly peak NDVI was at least 0.35 in each of 2013, 2014 and 2015 and below 0.25 in each of 2023, 2024 and 2025.

Drop test. A pixel is converted if the median of its yearly peak was at least 0.45 in 2013–2015 and below 0.40 in 2023–2025, with a fall of at least 0.20. This was added after the strict test turned out to miss most brick-kiln land: at 30 m a kiln field is a mixture of kilns, drying rows, tracks and weeds, and its pixels sit between 0.25 and 0.45, not below 0.25.

Each test is also run in reverse (low to high), which gives a measure of noise. Results are reported for three strata: the terraces; other flat, raised land, which is every delineated flat top that is not a terrace (mostly fans and valley fill with a scarp share below 0.25, plus the four flat tops removed by review and three that fall below 0.05 km^2 at the edge of the box), the natural comparison; and the rest of the box. Converted pixels sit in a few clusters, so a ratio of pixel rates between strata describes where conversion is concentrated and is not a test. Section 4.3 therefore also compares whole polygons.

For the long view I take, for seven periods between 1993 and 2025, the median of the yearly peak over three usable years in the adjusted Landsat series and count the land where it is below 0.35. The years are 1993, 1994 and 1998; 1999, 2000 and 2002 (2001 is left out as anomalous, Section 4.6); 2003, 2005 and 2007; 2008, 2010 and 2012; 2013–2015; 2018–2020; and 2023–2025. Two site boxes, drawn after the pattern had been seen, separate the kiln belts: Rangeen Kultreh, 74.83°–74.87° E and 33.925°–33.958° N, and Bandagam–Batapora, 74.60°–74.72° E and 33.99°–34.05° N.

3.5 Accuracy sample

I drew two random samples of points on terraces. The first has 120 points: 25 from pixels flagged by the strict test, 60 from pixels flagged only by the drop test, and 35 from pixels flagged by neither. The second, drawn later from the same strata by the same rule and leaving out the pixels already sampled, has another 120: 35 strict, 60 drop-only and 25 unflagged (`12_accuracy_sample_supplement.py`). Pooled, the strata hold 60, 120 and 60 points. In both samples the points were shuffled and the stratum of each point was kept in a separate file that I did not open until the labelling of that sample was finished.

First sample. For each point I opened the most recent satellite view in Google Maps, in October 2026, and recorded what lies at its centre. The acquisition date of that imagery was not recorded point by point; Google's newest image differs between places. The classes were kiln ground, vegetated, built-up, road, other bare ground, water or unclear. Because bare worked ground inside a kiln field cannot be told from other bare

ground at close zoom, the 68 points first labelled as bare or road were looked at a second time, one zoom level out, with a single question: is the point inside a brick-kiln field or not.

Second sample. For each point I took, in Google Earth Pro, the newest image and the September 2014 image (or the nearest clear image of 2013–2015 where that was cloudy or hazy), with the dates recorded point by point; the newest images range from 2022 to 2026. Labels were drafted from screen captures of the two images and I confirmed every one on screen. Each point was given one present class (kiln, vegetated, built-up, road or other bare ground), judged in a single pass against its setting: bare worked ground, a track or a yard inside a kiln field was counted as kiln. Each point was also given an earlier class (vegetated or not vegetated). Two points had no clear image in 2013–2015 and count as unclear for the earlier state.

One rule for the edge of a kiln field. Pooling the two samples showed that they had placed the edges of kiln fields differently (Section 4.5). I then wrote the rule down (`KILN_FIELD_RULE.md`): a point is inside a kiln field if it lies on a kiln, chimney, clay pit, rows or stacks of drying bricks or a kiln shed, or if it lies on bare worked ground, a track or a yard within the outer bunds or cut edges of the worked area, with brick rows, pits or a kiln within about 100 m (three Landsat pixels) and no house, public road or crop field in between. A public or paved road is road, a house or village yard is built-up, bare ground with nothing kiln-like within 100 m is other bare ground, and a field or orchard beside a kiln field is vegetated. Every flagged point whose kiln label had depended on its setting was then relabelled under this rule on the newest Google Earth Pro image, viewed from directly above, with the date recorded: the 57 first-sample points first labelled bare ground or road, and the 29 second-sample kiln points on edges, tracks, yards or cleared ground (`kiln_edge_recheck.csv`). Labels were drafted from screen captures and I confirmed every one. This pass was not blind to stratum. The other points keep their labels; the figures in Section 4.5 use the relabelled set (`16_kiln_rule_result.py`).

Shares are reported with Wilson (1927) intervals and converted to areas by stratum, in the manner recommended by Olofsson et al. (2014). Each stratum is a simple random sample in both draws, so the pooled points are treated as one sample per stratum (`15_pooled_accuracy.py`).

To check the earlier state in the first sample I then looked up each of its 85 flagged points in the historical imagery of Google Earth Pro and recorded what lies at the point in 2013–2014: vegetated (crop field, orchard, grass, or scattered trees and scrub), not vegetated (kiln or dug ground, building, road, track or bare soil) or unclear. I used September 2014 imagery, mostly the image of 10 September, for 77 points, and a clear image between June 2013 and July 2014 for the other eight, where the September image was under cloud, in cloud shadow or too hazy; the date is recorded for each point. Labels were drafted from screen captures of each point and I confirmed every one on screen, going back for a closer view, a view from directly above or another date where the first view did not settle it. This pass was not blind: only flagged points were examined, and I knew they were flagged. In the second sample the earlier state was labelled for every point, blind to stratum.

3.6 Elevation

To test whether the ground was lowered I compared the Copernicus model with SRTM (2000) and ALOS World 3D (2006–2011), and with GEDI laser ground returns for 2019–2025 (Dubayah et al., 2020).

3.7 What was dropped from the earlier version

The road and settlement proximity tests, the compactness and slope comparison, the saffron proximity analysis and the rupee valuation all depended on the earlier degradation layer. Since that layer does not stand, neither do they, and they are not repeated here.

4. Results

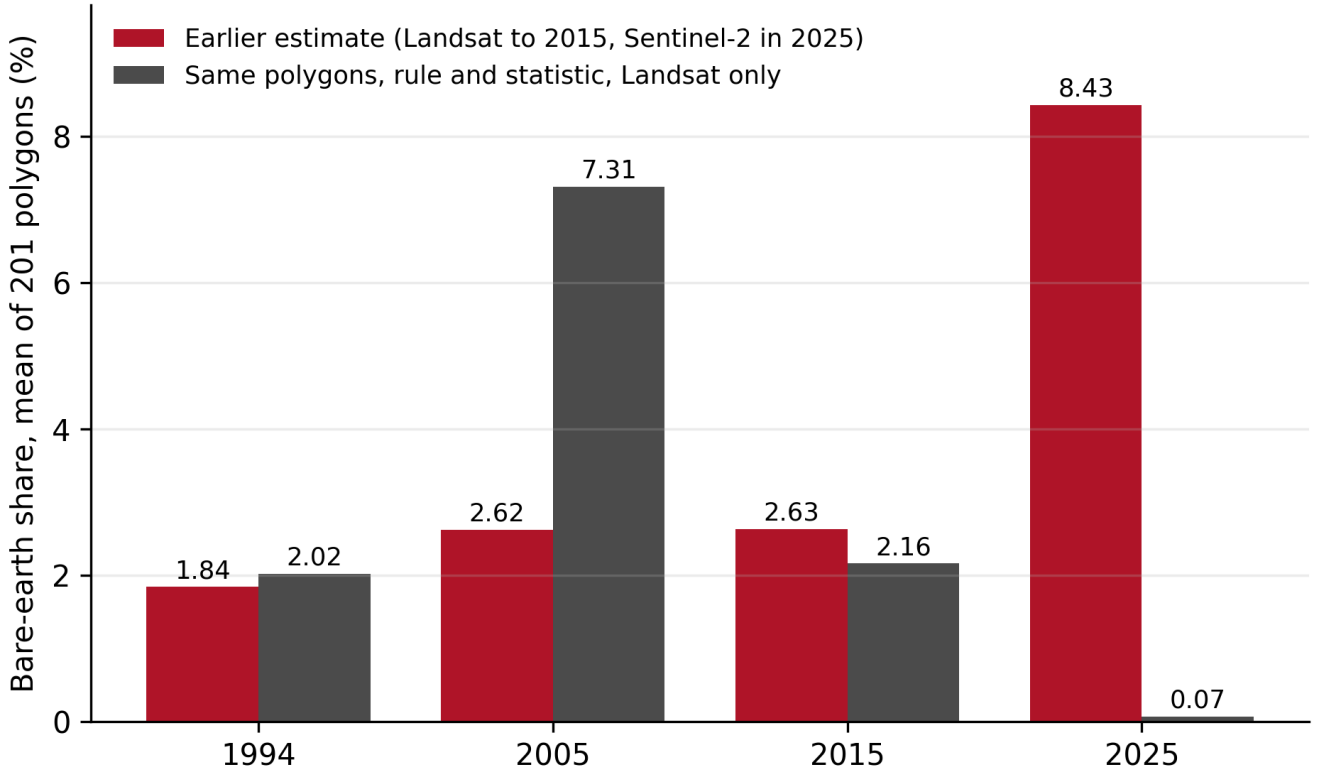
4.1 The earlier estimate was an artefact of mixing two satellite products

The earlier version classified a pixel as bare when its June–September NDVI was below 0.15, and reported bare-earth shares of 1.84% (1994), 2.62% (2005), 2.63% (2015) and 8.43% (2025) on 201 terrace polygons. Each figure was the unweighted mean of the 201 per-polygon shares. The first three came from Landsat composites built over several years and the last from a Sentinel-2 composite.

Applying the same threshold to the same 201 polygons with Landsat throughout, and taking the same mean of polygons, gives 2.02% for 1994, 7.31% for 2005, 2.16% for 2015 and 0.07% for 2025 (Figure 2). Pooling all pixels instead of averaging polygons gives 1.15%, 5.47%, 1.11% and 0.09%. Either way the 2025 jump is not there. The 2015 and 2025 values in this check use the adjusted Landsat series of the original box, which still carries the reversed Landsat 8/9 adjustment of the first run (Section 3.3) and has not yet been recomputed. The comparison is not exact in one other respect: the Landsat-only values use the June–September median of a single year, where the earlier version used composites of several years, so the earlier columns are not expected to agree closely.

Pixel size is not the explanation. Averaging the earlier Sentinel-2 composite onto the 30 m Landsat grid still gives 7.58%. On the same polygons in 2025 the median NDVI of that Sentinel-2 composite is 0.35, against 0.50 in the Landsat series. A gap of that size is more than the difference in band placement between the two instruments normally produces. The jump therefore came from comparing two differently built products, and I have not isolated which part of the Sentinel-2 processing (cloud masking, compositing or reflectance level) is responsible. A Sentinel-2 composite built exactly like the Landsat one would settle that. It would not change the conclusion that the 8.43% was not a change on the ground.

Two further things came out of this check. First, the summer median is not a usable measure in this valley. Before 2009 a terrace pixel had between 0 and 8 clear summer observations a year because of monsoon cloud, and the summer bare share swings from under 1% to 16% and back within a few years around 2000. The high 2005 value in the paragraph above is part of that noise. Second, the level of any bare-share figure depends on the instrument. On the terraces of the original box in 2025, the share of pixels with a yearly peak below 0.25 is 1.6% in the adjusted Landsat series (first run, not yet recomputed), 2.3% in Landsat 8/9 unadjusted and 4.7% in Sentinel-2. A statement of the form "x% of the karewas are bare" has no single answer. Only change measured within one instrument is defensible, and the rest of this paper is confined to that.



4.2 The terrace map

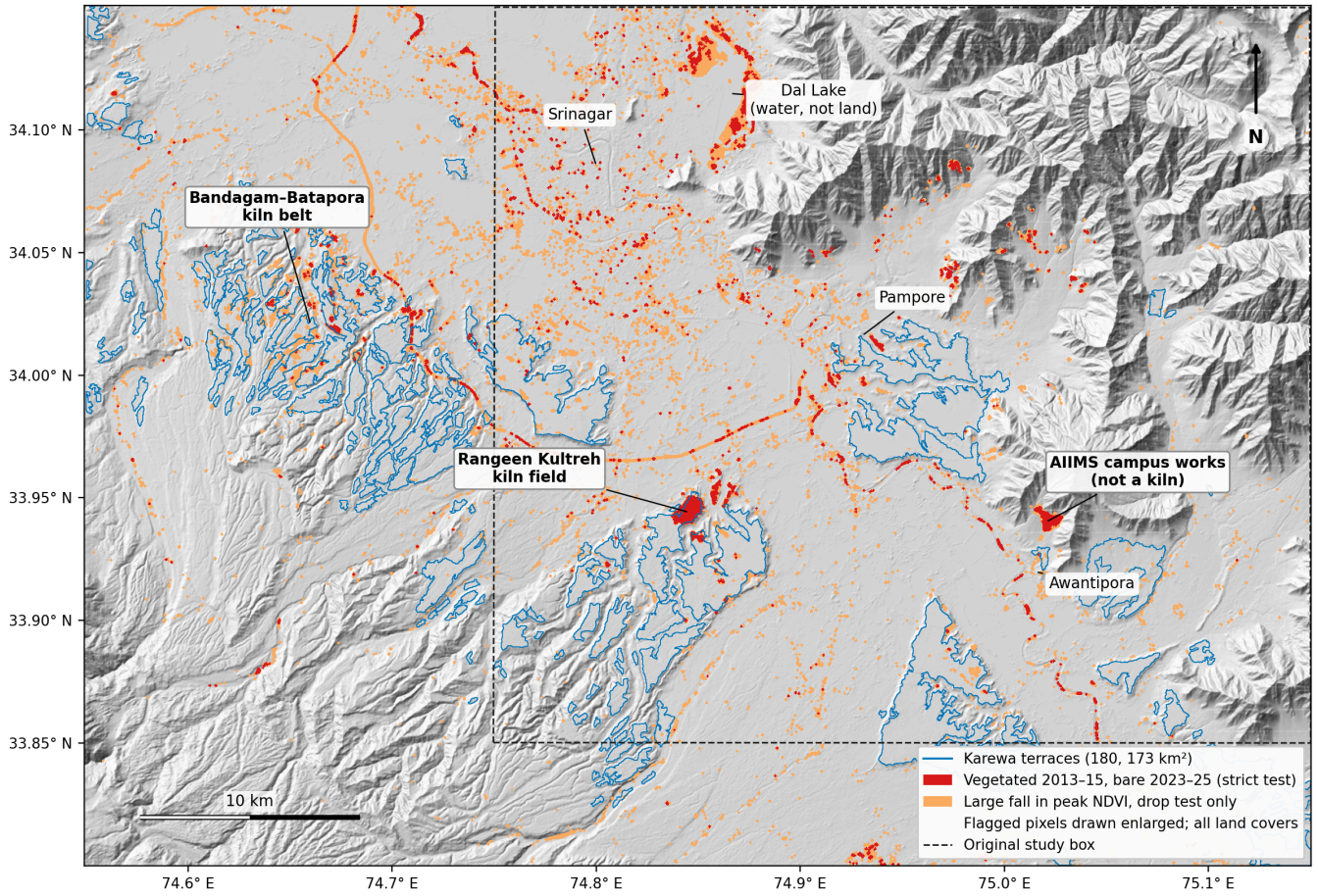
The rule yields 274 flat tops in the wide box, of which 187 have a scarp share of 0.25 or more. Four are dropped because they match the flat tops removed in the original box (Section 3.2) and three fall below 0.05 km² once clipped to the box. The remaining 180 terraces cover 173.3 km² (Figure 1). The other flat, raised land covers 161.9 km².

Against the geological map, in the original box where the map was georeferenced, 80% of the terrace area lies on Karewa formations and 20% on alluvium (computed on the original-box run of the same rule, 57 terraces of which 80.9 km² fall on the map; the wide-box terraces west of about 74.66° E, which include the Bandagam–Batapora belt, are not covered), with none on reworked karewa sediments; shifting the map by up to 600 m in any direction, which is within its positional error, moves the 80% between 67% and 89%. The flat tops the rule rejects are 30% Karewa formation, 36% reworked sediments and 35% alluvium, which is what a fan is. Scarp share and share on Karewa formations are correlated across the 44 flat tops large enough to compare (Spearman 0.58).

A ground check at Lethpora. The four photographs that the earlier map missed were taken on 3 September 2026 with a GPS camera that prints the position on each image, all within about 50 m of one another on the Lethpora tableland beside the national highway. They show tilled saffron beds and scattered trees. All four fall inside one of the new terraces (7.7 km²), between 540 and 570 m from its edge, and none falls on flagged land: the nearest drop-test pixels are about 400 m away and the nearest strict-test pixels about 4.5 km away. What the ground shows, a cultivated tableland, agrees with what the map and the tests say about that spot (`05_field_photo_check.py`, `field_photo_check.csv`). It is one place on one day, so it is a check on the map and not a validation of it.

The weak direction is coverage. The terraces include only 24% of the Karewa formation area the map shows in that box, and 38% of the flat part of it. Karewa ground that slopes gently without a bounding scarp, or that lies low near the valley floor, is not in the map. Section 4.6 shows that, as far west as the map reaches, this

omitted karewa ground converts no faster than ordinary valley floor by either test, so within that area the omission does not hide a second area of loss; the unit of study is still scarp-bounded tableland and not the Karewa Group as a whole.



4.3 Conversion after 2013

Table 1 gives both tests for 2013–2015 to 2023–2025 in the Landsat 8/9 series.

Table 1. Land converted from vegetated to not vegetated, 2013–2015 to 2023–2025.

Stratum	Area (km²)	Strict test (ha)	Strict (%)	Drop test (ha)	Reverse (ha)	Drop (%)
Terraces	173.3	107.0	0.62	328.6	42.8	1.90
Other flat, raised land	161.9	11.4	0.07	92.7	52.2	0.57
Rest of the box	1,826.6	329.0	0.18	2,049.8	547.9	1.12

Taken as a whole, the terrace stratum converts about nine times faster than other flat, raised land by the strict test and about three times faster by the drop test. These rates divide by the whole area of each stratum, not by the part that was vegetated in 2013–2015, and the difference comes entirely from the two kiln belts (Section 4.6). Outside the two site boxes, terraces convert at 0.045% by the strict test and 0.52% by the drop test, against 0.071% and 0.57% on other flat, raised land. Compared polygon by polygon, the same holds: over all polygons, 15% of terraces and 18% of other flat tops lose a hectare or more by the drop test, and the converted share of a polygon is not higher on terraces (one-sided Mann–Whitney p = 0.68 for the drop test,

0.61 for the strict test; 180 terraces, 94 other flat tops). Terraces are not, as a class, more exposed than comparable land; a few terraces in two places are. On terraces the reverse change is small next to the forward change (5.3 ha against 107.0 ha for the strict test, 42.8 ha against 328.6 ha for the drop test). Off the terraces the drop test picks up a great deal of change in both directions, which is what fields, building and road works produce, and I do not interpret those numbers further.

A second instrument agrees on the change and a third on the end state. For the window that Landsat 7 can cover (2013–2015 to 2019–2021) Landsat 7 alone gives 70.8 ha by the strict test on terraces and Landsat 8 gives 68.6 ha; Landsat 7 confirms 86% of the Landsat 8 drop-test pixels. Sentinel-2, which starts in 2019, puts 97% of the strict-test terrace pixels below 0.25 in each of 2023, 2024 and 2025 (against 0.9% of the terrace pixels that Landsat 8/9 calls vegetated in those years), and its median over the drop-test pixels is 0.17.

The strict test is concentrated to an unusual degree. Eight of 180 terraces have a hectare or more, and two adjoining terraces at Rangeen Kultreh hold 87.8 ha, 82% of the total. The drop test spreads further: 27 terraces lose a hectare or more and 13 lose five or more, a cluster of them on the Bandagam–Batapora tablelands near 34.02° N, 74.66° E. Rangeen Kultreh accounts for 37% of the drop-test area.

4.4 Does the result depend on my choices?

Terrace cut-offs. Re-running the delineation with slope limits of 3°, 4° and 5° and HAND limits of 10, 15 and 20 m changes the terrace area from 106 to 258 km^2. The strict conversion stays between 95 and 120 ha and the drop conversion between 221 and 422 ha. Terraces convert 5 to 13 times faster than other flat land by the strict test and 2.4 to 3.7 times faster by the drop test in all nine versions. The HAND limit matters little; the slope limit matters more.

Strict-test thresholds. In the original box, 24 variants (bare below 0.20, 0.25 or 0.30; four vegetated limits; all three years or two of three) give 37 to 151 ha on terraces. In every variant 80% to 99% of it is on the Rangeen Kultreh terraces.

Drop-test thresholds. Twenty-seven variants give 234 to 374 ha net of reverse change, with terraces converting 1.9 to 5.7 times faster than other flat land.

So the hectares move with the thresholds, as they must, but the location of the change does not. The ratios to other flat land carry the caveat of Section 4.3: they are driven by the same two belts in every variant.

4.5 Accuracy

Table 2. What the sample points are in the most recent imagery (both samples pooled, kiln-field edges under one rule).

Stratum (terraces)	Points	Area (ha)	Kiln field	Built-up or road	Other bare	Still vegetated	Unclear
Flagged by strict test	60	107	56	3	1	0	0
Flagged by drop test only	120	224	59	30	14	16	1
Not flagged	60	17,000	1	8	11	40	0

Both tests are right that the vegetation is gone: all 60 strict points (95% interval 94–100%) and 103 of 120 drop-only points (86%, interval 79–91%) are not vegetated today; of the other seventeen, sixteen are still vegetated and one could not be told. Scaled by stratum area, about 299 ha of the 331 ha flagged is not vegetated today (interval roughly 285 to 313 ha). The tests differ in what the land became. Almost all strict detections lie inside a kiln field (93%, interval 84–97%). Drop-only detections are a mixture: about half kiln field (49%, interval 40–58%), a quarter built-up land and roads (25%), about an eighth other bare ground (12%), 13% false alarms and one point that could not be told.

Scaling by stratum area, land inside a kiln field makes up about 100 ha of the strict detections and about 110 ha of the drop-only detections, 210 ha together, with a 95% interval of roughly 189 to 231 ha. This is the figure I put forward for karewa tableland that the satellite record shows as vegetated in 2013–2015 and that lies inside a brick-kiln field today. Whether the land was in fact vegetated before is taken up at the end of this section.

Where a kiln field ends. Before the rule of Section 3.5 was written, the two samples gave different kiln figures: 141 ha (interval 110–172 ha) from the first and 232 ha (interval 202–261 ha) from the second, and in the drop-only stratum the difference was too large to be chance (16 of 60 points against 35 of 60; Fisher's exact test, p = 0.001). The points themselves were not different: kiln field, other bare ground and road together took 40 of the 60 drop-only points in the first sample and 43 in the second, and the not-vegetated and earlier-vegetated figures agreed closely. What differed was where bare worked ground, tracks and cleared plots at the edge of a kiln field went: in the first sample mostly to other bare ground or road, in the second mostly to kiln. Under the one rule the two samples agree: 204 ha (interval 174–233 ha) from the first and 217 ha (interval 187–248 ha) from the second, with 27 and 32 of 60 drop-only points inside a kiln field (p = 0.47). The rule changed 27 labels: 16 first-sample points moved into a kiln field, 4 second-sample points moved out of one (three to other bare ground, one to unclear), and the rest changed between classes other than kiln (Table 3).

Table 3. The kiln estimate by sample, before and after one rule for the edge of a kiln field (flagged land, both strata).

Sample	Points	Labelled as in the sample	Under one rule
First sample	85	35 points, 141 ha (110–172)	51 points, 204 ha (174–233)
Second sample	95	68 points, 232 ha (202–261)	64 points, 217 ha (187–248)
Both samples pooled	180	103 points, 188 ha (166–210)	115 points, 210 ha (189–231)

In the first sample, before the rule, counting only points labelled kiln ground at close zoom gave about 40 ha. So most of the 210 ha is recognised as kiln land from its setting inside the worked area, within about 100 m of bricks, pits or a kiln, and not from what lies under the point itself. An outline of each kiln field drawn on dated imagery would give an independent area.

The strict stratum is also concentrated. Forty-four of its 60 points fall on one terrace and 52 on the two Rangeen Kultreh terraces (51 of these 52 are labelled as inside the kiln field), because that is where 82% of the strict-test area lies. The 93% for the strict test is in effect a description of that one field.

Were the flagged points vegetated before? The labels above describe the present state. For the earlier state I looked up the 180 flagged points in imagery of 2013–2015 (Section 3.5). Vegetation is visible at 158 of them: at 59 of the 60 strict points (98%, interval 91–100%) and at 99 of the 120 drop-only points (83%, interval 75–88%). Twenty-one points were not vegetated in the older image and one could not be told (Table 4). Scaled by

stratum area, about 290 ha of the 331 ha flagged was vegetated in the older image (interval roughly 274 to 306 ha).

Table 4. The flagged sample points in imagery of 2013–2015 (both samples pooled).

Stratum (terraces)	Points	Vegetated	Not vegetated	Unclear	Vegetated then, not vegetated now	Vegetated then, inside a kiln field now
Flagged by strict test	60	59	1	0	59 points, 105 ha	55 points, 98 ha
Flagged by drop test only	120	99	20	1	84 points, 157 ha	53 points, 99 ha
Flagged land together	180	158	21	1	143 points, 262 ha	108 points, 197 ha

In the first sample the twelve points not vegetated before fall into four groups of three: ground that was already cut kiln benches or rows of drying bricks in 2014 (points 27, 30, 32); buildings or hard ground inside a compound or a settlement (79, 87, 114); bare ground and tracks beside sheds and other structures (8, 39, 69); and bare soil plots with no crop at the image date (20, 78, 106). The nine in the second sample are of the same kinds: yards and roofs in villages and towns (165, 179, 185, 229), a construction site (160), an unpaved road (191), a track and a cleared strip at the edge of kiln ground already working in 2014 (177, 182), and a bare plot at the edge of a kiln field (123). Every one of these pixels had a median yearly peak NDVI of at least 0.45 in the Landsat record of 2013–2015, so at these points the picture and the satellite record disagree. I see two ordinary reasons and cannot separate them. A 30 m pixel mixes the point with greener ground beside it, and one image shows one day while the test uses the peak of the year. Point 78 looks like the second case: intact farmland laid out in small bed plots, bare in a June image.

Seven of the twenty-one are points counted as kiln field today. If the kiln estimate is restricted to points where the older image also shows vegetation, it falls from 210 ha to about 197 ha (108 points; interval roughly 176 to 218 ha). I keep 210 ha as the estimate defined by the satellite test, and give 197 ha as the figure for land that an independent image shows as vegetated in 2013–2015 and that lies inside a brick-kiln field today. Land vegetated in the older image and not vegetated today, whatever it became, comes to about 262 ha of the 331 ha flagged (interval roughly 243 to 281 ha).

"Vegetated" in this pass is a low bar. It covers rough grass and scattered trees and bushes on dry ground as well as crop fields and orchards. At Rangeen Kultreh, before the kiln field, the points show scattered trees and bushes and not dense cover.

One caution belongs here and not only in the limitations. Twenty of the 60 unflagged points also look non-vegetated in the recent image, because a dry-season picture of a karewa is largely brown. Present-day bareness on its own means little. The tests rest on the change in the satellite record.

4.6 Where and when

Rangeen Kultreh. On the terraces around 33.94° N, 74.85° E the land with a yearly peak below 0.35 was 1 ha in 1993–1998, 14 ha in 1999–2002, 0 ha in 2003–2007 and in 2008–2012, 7 ha in 2013–2015, 106 ha in 2018–2020 and 125 ha in 2023–2025, a quarter of those terraces (Figure 4). The 1999–2002 values are raised on

every kind of land (6.5% on all other terraces, against 3.0% before and 3.3% after), which I read as noise in the thin record of those years and not as change. In the Landsat 8/9 series the terrace land inside the Rangeen Kultreh site box has 0.4 ha below 0.25 in 2013, 24 ha in 2017 and 75 ha in 2018 (Figure 3). The pixels that later converted had a median yearly peak between 0.44 and 0.63 in every usable year from 1993 to 2016 except 2001 (0.31), a year in which the whole series is anomalous: 11% of all terrace pixels read as bare, against about 2% in the years on either side. Present-day imagery shows a dense field of kilns with rows of drying bricks, and the map carries the names of individual kilns. One of those names is the kiln in the National Green Tribunal filing (JKPCC, 2024), which states that it was commissioned in 2017. The closure order of 10 September 2018 annexed to that filing lists three kilns at Kultreh among 32 in the district then in operation without consent, and the filing's list of 37 consent applications refused in 2023 includes eight from Rangeen Kultreh. The district list of October 2023 has six entries for the village: three kilns standing, one with consent and two under closure orders, and three with consent to establish that were not yet built (JKPCC, 2023b). I obtained the satellite onset before I found that document.

Two press reports, in the same words, say the roughly two dozen kilns at Rangeen Kultreh were built between 2003 and 2012, with none permitted from 2013 to 2022 (Bhat, 2023; Kashmir Despatch, 2023). The satellite record shows this block fully vegetated until 2016. Either the older kilns stand in another part of the village or the reported dates are wrong. The official filing agrees with the satellite record, and the district list of 2023 has nothing like two dozen kilns under this village's name. I have not resolved this.

Bandagam–Batapora. On the tablelands between about 74.60° and 74.72° E and 33.99° and 34.05° N the same measure goes from 102 ha (3.7% of those terraces) in 1993–1998 to 304 ha in 2008–2012 and 454 ha (16.3%) in 2023–2025. The rise is not steady: across the seven periods the values are 102, 173, 162, 304, 318, 348 and 454 ha. It grew in two steps, up to about 2010 and again after 2018–2020. The first step lies in the thin part of the record. The second is measured in the Landsat 8/9 series and is not small: between 2013–2015 and 2023–2025 the drop test flags 142 ha on these terraces (119 ha net of change in the opposite direction), more than at Rangeen Kultreh (114 ha). The strict test sees little of it (15 ha) because kiln ground here stays partly green at 30 m (Section 3.4). So this belt is not only older; it also holds the largest area of recent loss by the looser test. Imagery shows kiln ground across the villages of Bandagam, Chand Pora, Hardu Bata Pora, Nijlu and Bonahama. The district list of October 2023 has kilns under most of these names: twelve at Chandpora, six at Bonhama, and others at Batapora, Harda Batapora, Bandgam and Nigloo (JKPCC, 2023b). Several hold consents first issued between 2011 and 2014. The list gives village names and no coordinates, so it shows that kilns are registered in these villages and not that any one of them stands on a mapped terrace; that still rests on imagery.

Everywhere else. On the remaining 140 km² of terraces the low-NDVI land was 417 ha (3.0%) in 1993–1998 and 400 ha (2.8%) in 2023–2025. Conversion there after 2013 is not zero (6 ha by the strict test, 72 ha by the drop test, 53 ha net), but it runs at the rate of other flat, raised land (Section 4.3).

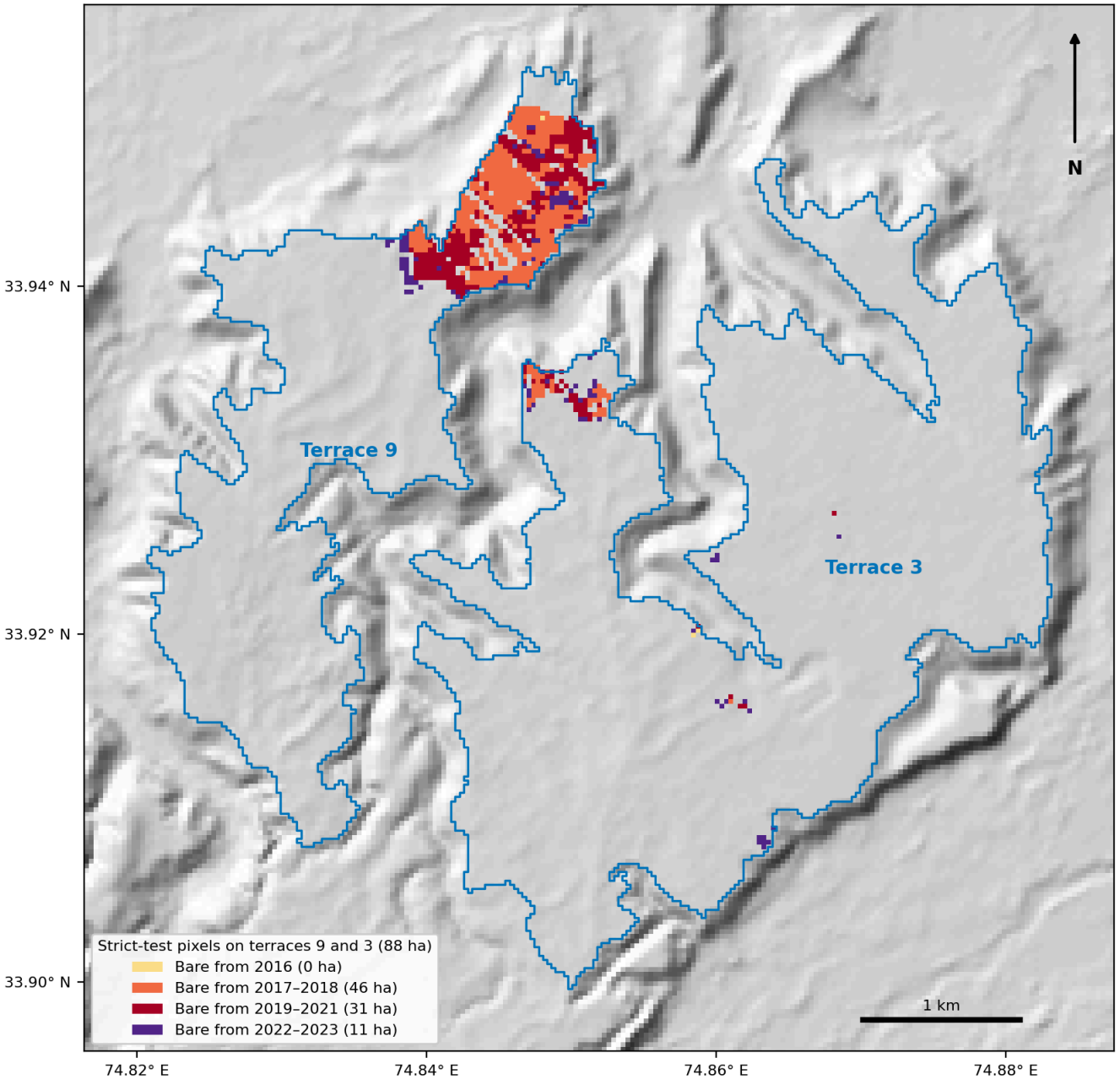
Running the drop test from 1993–1998 to 2023–2025 in the adjusted Landsat series gives, net of reverse change, +98 ha at Rangeen Kultreh and +309 ha at Bandagam–Batapora, about 407 ha together, and −202 ha on all other terraces. Peak NDVI is higher everywhere from 2013 because Landsat 8 adds observations (the terrace median rises from 0.58 in 2008–2012 to 0.64 in 2013–2015), which pushes this long comparison toward greening. That bias works against the losses reported for the two belts, not for them, and it is the reason I do not read the −202 ha as real greening. The first run of this series, with the Landsat 8/9 adjustment in the reverse direction (Section 3.3), gave +92 and +243 ha (about 335 ha) and −336 ha; correcting it made the step at 2013 smaller and the losses in both belts larger.

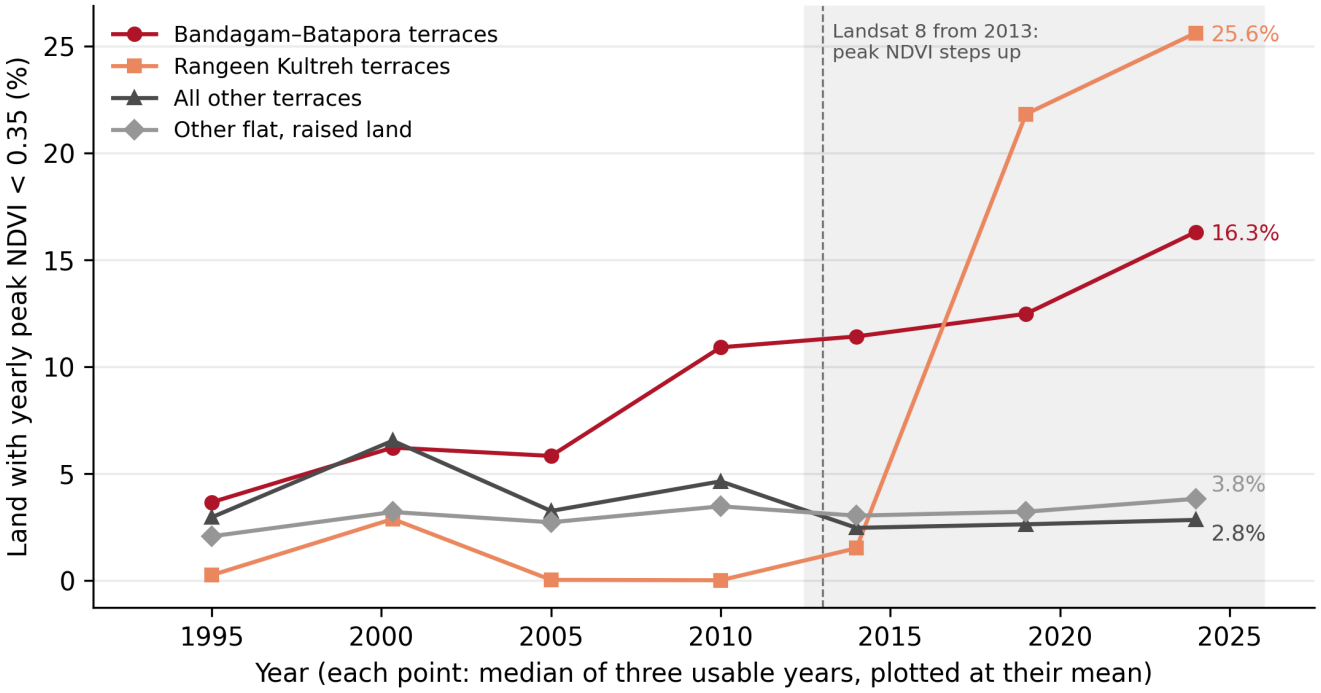
I treat the 407 ha as indicative, and not as a measurement of the same standing as the 2013–2025 figures, for three reasons. The two site boxes were drawn after the pattern had been seen. Over all terraces together the same long test gives 622 ha of loss against 417 ha of change in the opposite direction, and outside the two belts the net is −202 ha, so the belts stand out against a background that leans the other way. And before 2013 the low-NDVI land on the other terraces moves between 417 and 921 ha from one period to the next, which is as large as the signal. The Rangeen Kultreh part (+98 ha) is firm, because all of it happens after 2016 and is seen in the Landsat 8/9 record as well. The Bandagam–Batapora part (+309 ha) shows a direction and not a reliable amount.

Is karewa being lost outside the mapped terraces? The geological map reaches west to about 74.66° E. Over that part of the wide box, below 2,000 m, Karewa formation outside the terraces lost 0.14% of its vegetated land by the strict test and 0.95% by the drop test; alluvium outside the terraces lost 0.19% and 1.75%; Karewa formation inside the terraces lost 0.95% and 2.03%. With the two kiln-belt boxes removed, Karewa formation inside the terraces falls to 0.05% and 0.53%. The karewa ground my terrace rule leaves out converts no faster than ordinary valley floor by either test. West of 74.66° E there is no geological map, so this cannot be checked there.

What else the test finds. The largest clusters off the terraces are the AIIMS campus under construction at Awantipora (37 ha on a hillside), about 58 ha inside Dal Lake where floating vegetation gave way to open water, road works and shifts of the Jhelum channel. The test detects loss of vegetation from any cause, which is why the kiln figure comes from the labelled sample and not from the test alone.

Rangeen Kultreh: year from which each strict-test pixel stays bare (peak NDVI < 0.25) to 2025
Landsat 8/9 only, 30 m; terrace numbers of the wide-box run; Copernicus DEM hillshade





4.7 Saffron

The saffron-signature polygons of the earlier version lie around Pampore, 7 km or more from the Rangeen Kultreh kiln field, and 0.2 ha of all strict-test conversion on the terraces of the original box falls within a kilometre of them. The terraces outside the two kiln belts, which include the Pampore and Lethpora tablelands, convert at 0.48% by the drop test in the adjusted Landsat series, against 0.49% for other flat land. I therefore find no evidence in 2013–2025 that the saffron tablelands are being converted in the way the Budgam tablelands are. The one spot I photographed on the ground, saffron beds on the Lethpora tableland (Section 4.2), is on a mapped terrace and on land neither test flags. This says nothing about saffron decline from other causes, about villages where saffron was grown in the past and is no longer, or about the earlier decades for which the record is thin.

4.8 How deep

The three elevation models all predate the Rangeen Kultreh kiln field, and their differences over the converted block match the unconverted part of the same terraces to within noise (0.6–1.3 m). GEDI is precise enough on these flat surfaces (about 0.7 m), but only nine 30 m cells with usable shots fall on the converted block, all from 2019; they show no lowering relative to the 2011–2015 surface (−0.3 m, against −0.5 m on the untouched part of the terrace that year). Nine cells support no conclusion in either direction. I cannot say how deep the ground was dug or how much material left.

5. Discussion

The measured change is more limited and more localised than the reporting on the karewas suggests. Across 173 km^2 of mapped tableland, conversion of vegetated land after 2013 is rare. Where it happens it is mostly in two places, and in both it is brick kilns. Rangeen Kultreh is the clearer case because the change there is recent and complete: vegetated in every usable year to 2016, then a kiln field over a quarter of the terrace within three years, confirmed by three instruments and dated independently by a regulator's filing. Bandagam–Batapora is different in kind: land with little vegetation was already widespread there in the 1990s, though that

early history rests on the thin part of the record, and the belt also holds the largest area of post-2013 loss found by the looser test, spread over many patches rather than one block.

The two tests also differ in what they catch. A threshold tuned on a site that was cleared completely will undercount sites that are cleared in patches. I trusted the strict test at first because it gave a clean answer at Rangeen Kultreh. Only when I looked at the imagery of the second site did I see that it was missing most of a kiln landscape several kilometres across. The looser test catches that landscape but also catches houses and roads, so its area cannot be read as kiln area without the sample.

The correction in Section 4.1 is relevant beyond this study. Many change analyses in data-poor regions are built the way my first version was: a handful of dates, the best available sensor for each, one threshold. The 2025 value in that version looked like a finding and was reported as one. Its robustness check tested pixel size, not the sensor. The check that exposed it cost one extra export. Running the full rule on a single sensor family, even a coarser one, is a simple check to make before reporting a cross-sensor change.

On regulation, the documents describe a district where a large share of kilns run without valid consent and where the Rangeen Kultreh kiln named in the tribunal filing was ordered closed in 2018 and in 2023 applied for consent to operate as an existing kiln. This study does not test whether enforcement would have prevented the conversion. It does give regulators something they did not have: dated, mapped areas for the two belts, and evidence that the most complete recent conversion began in 2017.

6. Limitations

- **The terrace map is a subset of the karewas.** It captures scarp-bounded tablelands, 24% of the mapped Karewa formation area in the original box. The geological reference is a schematic published figure with a positional error of roughly a kilometre, it was used only for the original box, and the strip west of about 74.66° E, which includes the Bandagam–Batapora belt, has no geological check. The official Geological Survey of India layer could not be obtained. The terrace map has no accuracy figure of its own: a 460-point reference sample was drawn for it and has not been labelled.
- **The elevation model dates from 2011–2015.** Tableland removed before then may no longer register as a flat top and would be missing from the terrace map.
- **The accuracy samples rest on one labeller's judgement.** 240 points, of which 60 are in the strict stratum, and one image date for the present state of each point. For roughly eight uncertain points in the first sample I took a second opinion while labelling; the rest I labelled alone. Labels of the earlier state, and all labels of the second sample, were drafted from screen captures and confirmed by me on screen. The first sample's check of the earlier state covers only its 85 flagged points and was not blind. A single image shows one day, so it can neither confirm nor contradict a yearly peak exactly, and 21 of the 120 drop-only points were not clearly vegetated in it. A second, independent labeller is still missing.
- **Missed kiln land is not estimated.** One of 60 unflagged points was kiln ground, which gives a range (50 to 1,505 ha) too wide to mean anything. The tests detect new loss; kiln land already bare before 2013 enters only through the long series.
- **Low NDVI is not excavation.** The tests detect loss of vegetation. Attribution to kilns comes from the sample, from imagery and from documents.
- **No depth or volume.** See Section 4.8.
- **Before 2013 the record is thin.** Six years have too few scenes to use, and the step in peak NDVI at the arrival of Landsat 8 biases long comparisons toward greening.
- **The cloud mask is not exhaustive.** It removes cloud, dilated cloud, shadow and snow. It does not use the high-confidence cirrus flag of Landsat 8/9 or the radiometric saturation band. Taking the yearly 90th

percentile should limit the effect of thin cirrus, which lowers NDVI, but I have not run the tests with those flags masked.

- **Thresholds are choices.** The sensitivity runs bound their effect; they do not remove it. The accuracy sample applies only to the thresholds actually sampled.
- **Documents were not all read in the original.** The tribunal filing for Rangeen Kultreh (JKPCC, 2024) and the district list of kilns (JKPCC, 2023b) I have read in full. The press reports and the April 2023 district report cited in Section 2.2 and Section 4.6 I have so far checked against extracts and summaries, not read through in the original. For the Bandagam–Batapora belt the only document is a list of registered kilns by village, without locations or dates of establishment.
- **The present-day reference imagery is not dated point by point.** The first sample's labels describe the newest image Google Maps showed in October 2026, whose acquisition date varies by place; in the second sample, where it was recorded, it ranges from 2022 to 2026. A point whose newest image predates 2023 is described before the end of the late window.
- **"Inside a kiln field" rests on a written rule and on judgement.** Labelled in two different ways, the samples gave 141 and 232 ha; under one written rule (Section 3.5) they give 204 and 217 ha. The rule was written after the two samples had been compared, and the relabelling was not blind to stratum. Most of the kiln area is recognised from its setting within about 100 m of bricks, pits or a kiln, not from what lies at the point. An outline of each kiln field drawn on dated imagery would give an independent area.
- **The long series was corrected once.** Its first run applied the Landsat 8/9 adjustment in the reverse direction (Section 3.3). The corrected run raised the three-decade figure for the two belts from about 335 ha to about 407 ha; it changed nothing in the 2013–2025 results, which never used the adjustment. The original-box series behind the Landsat values of Section 4.1 still carries the reversed adjustment.
- **Landsat 9 changes the number of scenes inside the Landsat 8/9 series** from 2022 (Section 3.3). The effect works against detecting loss; a Landsat 8-only run has not been made.
- **The earlier Sentinel-2 composite cannot be regenerated.** Its Earth Engine export script is not in the repository, so the step that produced the 8.43% cannot be isolated.
- **No fieldwork** was done at either kiln belt. The only ground photographs are four taken at one spot on the Lethpora saffron tableland (Section 4.2).

7. Conclusion

The claim that the bare-earth share of Kashmir's karewa terraces rose from 1.84% to 8.43% between 1994 and 2025 was wrong, and so was everything built on it. It came from comparing two differently built satellite products. Measured inside one sensor family, on tablelands mapped by their scarps and checked against geology, the answers to the three questions are these. (RQ1) Between 2013–2015 and 2023–2025, 107 ha of vegetated karewa tableland went bare by a strict test and 329 ha lost most of its vegetation by a looser one, out of 173 km^2. Outside two belts the tablelands convert no faster than comparable land. (RQ2) About 299 ha of the 331 ha flagged is not vegetated today, and about 262 ha of it was vegetated in imagery of 2013–2015. Under one written rule for where a kiln field ends, about 210 ha of the flagged land, somewhere between 189 and 231 ha, lies inside brick-kiln fields today, and about 197 ha of that was vegetated in the older imagery; the two accuracy samples agree on this once the same rule is applied to both. (RQ3) The change sits in two kiln belts in Budgam. The Rangeen Kultreh field did not exist before 2016 and opened in 2017–2018. The Bandagam–Batapora tablelands already carried land with little vegetation in the 1990s and lost the most land after 2013 by the looser test. A comparison back to the mid-1990s suggests a net loss of roughly 407 ha in the two belts, but the record before 2013 is too thin for that figure to carry the same weight. I could not measure depth, and I found no sign of the same process on the saffron tablelands of Pampore.

If the karewas are to be protected, this study points to a short and specific list of places, and one of them was vegetated land ten years ago. A satellite-based claim of this kind should also be tested on a single sensor before it is published; the first version of this paper was not.

Data and code availability

Scripts, result tables, the terrace layers and the labelled sample are in the project repository, github.com/sakshimaske303-commits/STOLEN_STRATA, under `v2_redesign`. The Earth Engine scripts there regenerate every raster of the revised analysis; `DATA_ACCESS.md` lists the files with SHA-256 checksums. The Sentinel-2 composite of the earlier version, used only in Section 4.1, has no export script in the repository. Landsat, Sentinel-2, Copernicus DEM, SRTM, ALOS World 3D and GEDI data are public.

Data acknowledgements

Landsat Collection 2 Level-2 surface reflectance courtesy of the U.S. Geological Survey. Contains modified Copernicus Sentinel-2 data (2019–2025). Copernicus DEM GLO-30: © DLR e.V. 2010–2014 and © Airbus Defence and Space GmbH 2014–2018, provided under COPERNICUS by the European Union and ESA. SRTM (Farr et al., 2007), ALOS World 3D-30m (JAXA; Tadono et al., 2014) and GEDI (Dubayah et al., 2020) were accessed through Google Earth Engine. Reference labels were made on Google Maps and Google Earth Pro imagery; the dashboard background is Esri World Imagery.

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