

Banana NDRE Canopy Chlorophyll and Maturity Assessment Report

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Executive Summary

Across the surveyed banana field, Red Edge Normalized Difference (NDRE) values average **0.407** (median 0.401, standard deviation 0.088) over a valid raster area of 2,755,174 pixels (54.9% of the raster extent). The distribution is comparatively narrow and centered well above zero: about 74% of valid pixels fall in the 0.30–0.50 band, roughly 15% reach 0.50 or higher, and only about 10% fall below 0.30. Relative variability is modest (coefficient of variation $\approx$ 21.5%), and spatial autocorrelation is very strong (Moran's $I \approx$ 0.87), indicating the canopy's Red Edge response changes gradually across the field rather than in a scattered or patchy way. A broad north-to-south gradient is present (thirds-of-field means: north 0.441, middle 0.409, south 0.373), while the west-east direction is comparatively flat. These are measured observations from the NDRE raster only; NDRE is interpreted here strictly as a spectral index, and no biological, disease, nutrient, pest, or water-stress diagnosis is made in this report.

Data & Methodology

This assessment uses only the NDRE raster layer from the project's QGIS workspace (`vegetation.qgz`): a single-band NDRE raster, 2,155 × 2,329 pixels at a native ground resolution of approximately 5 cm/pixel, projected in WGS 84 / UTM Zone 51N (EPSG:32651) — consistent with a high-resolution multispectral drone (UAS) orthomosaic collected over a banana plantation. Of 5,018,995 total pixels, 2,755,174 (54.9%) carry valid NDRE values; the remainder are flagged no-data, corresponding to the rectangular bounding extent around an irregular flight or field boundary rather than to canopy absence.

All statistics, value-range descriptions, and spatial observations in this report are computed directly from this single raster's pixel values. No vector layers, polygons, management zones, or anomaly boundaries were created, and no other project layers (NDVI, GNDVI, OSAVI, MSAVI, chlorophyll indices, RGB or multispectral composites, DEM, soil, drainage, irrigation, weather, or management-history data) were used. Local spatial variability was assessed using a 5×5-cell moving-window standard deviation computed on a 4× spatially downsampled version of the raster (582 × 538 cells) for computational tractability; large-scale spatial clustering was estimated with an approximate global Moran's I on the same downsampled grid. The descriptive NDRE bands used later in this report (below 0.30, 0.30–0.50, 0.50 and above) are fixed cut points applied only to label the existing pixel values — they are not derived classes, clusters, management zones, or spatial products.

NDRE Statistical Summary

All values below are measured directly from the 2,755,174 valid NDRE pixels.

Statistic	Value
Minimum	-1.048
Maximum	0.779
Mean	0.407

Median	0.401
Standard deviation	0.088
Coefficient of variation	21.5%
Skewness	0.23
Excess kurtosis	0.13

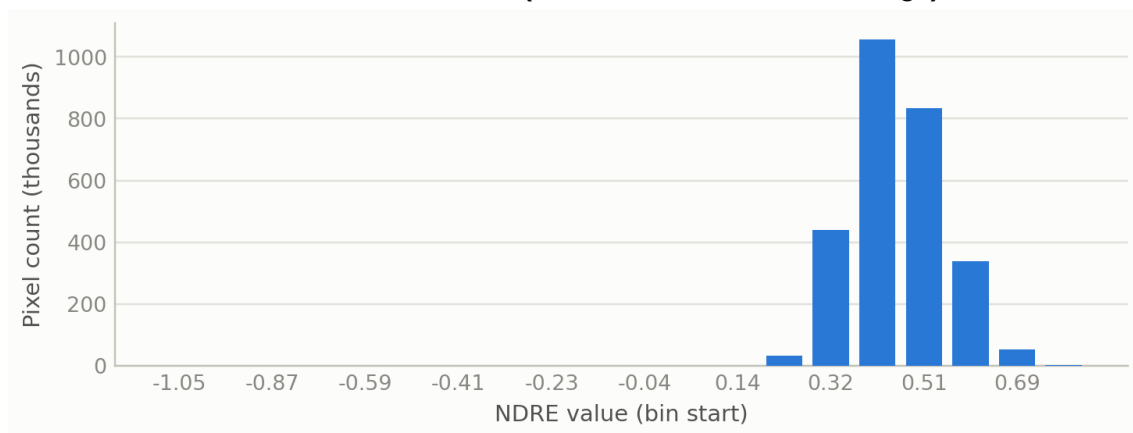
Percentile distribution

Percentile	NDRE
5th	0.273
10th	0.298
25th	0.344
50th (median)	0.401
75th	0.466
90th	0.526
95th	0.560

The gap between the 5th and 95th percentile (about 0.29 NDRE units) is comparatively narrow relative to the raster's full measured range (-1.048 to 0.779), and the interquartile range (25th–75th percentile, 0.344 to 0.466) spans only about 0.12 units. This tight core, examined further below, points to a canopy with a fairly consistent Red Edge response across most of its area.

NDRE Distribution & Red Edge Response (value-based)

NDRE value distribution (20 bins across measured range)



Counts of valid pixels per NDRE interval

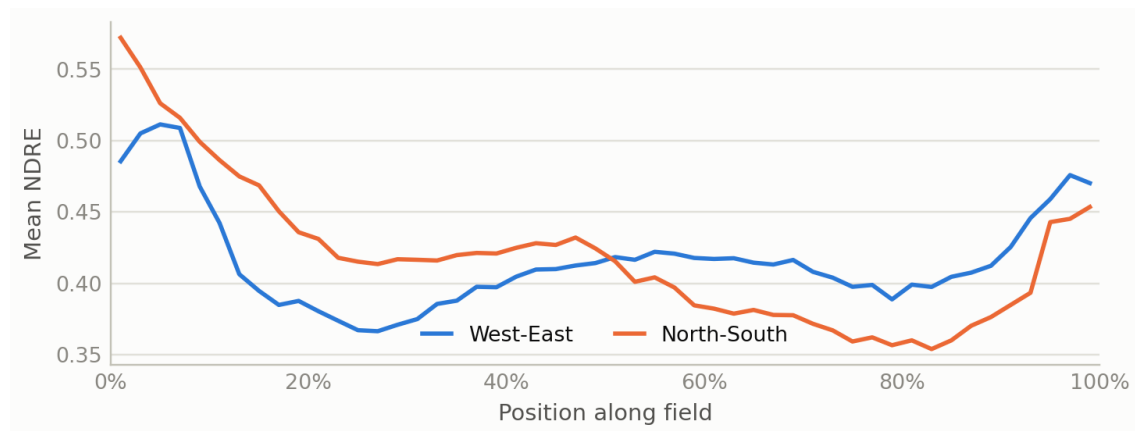
NDRE raster · 2,755,174 valid pixels · 20 bins, -1.05 to 0.78

The distribution is unimodal and comparatively tight around its peak: the 0.32–0.51 interval alone holds roughly 1.9 million pixels (about 70% of all valid pixels), with the single 0.41–0.51 bin the largest at 1,056,643 pixels (38.3%). Using the fixed descriptive bands introduced above, about 10.5% of valid pixels register a lower Red Edge response (NDRE below 0.30), 74.1% fall in the mid band (0.30–0.50), and 15.4% register a stronger response (0.50 and above). A very small number of pixels sit far outside this main cluster, extending down to NDRE -1.048; fewer than 0.01% of valid pixels (211 of 2,755,174) fall below 0.10, and only 76 pixels (0.0028%) are negative. Because these values are numerically isolated from the smooth main distribution and sit near or beyond the theoretical lower bound of the index, they most plausibly correspond to residual shadow, specular reflection, water, or non-canopy surface artifacts rather than banana canopy response — this is an interpretation, not a measured classification, and is flagged for visual or field confirmation rather than treated as canopy signal.

Relative variability (coefficient of variation $\approx 21.5\%$) is modest, reflecting a distribution that sits well above zero with a comparatively narrow spread: the interquartile range spans only 0.344 to 0.466. Skewness (0.23) and excess kurtosis (0.13) are both close to the values of a symmetric, moderately peaked distribution, describing a Red Edge response that is fairly evenly distributed around its central tendency rather than sharply lopsided or heavy-tailed — a markedly different shape from a distribution dominated by low or near-zero values.

Spatial Pattern Analysis

NDRE field transects



Mean NDRE by relative position, West-East vs North-South (50 bins each)

NDRE raster · 50-bin transects, each direction

The chart above averages NDRE over 50 equal-width bins along each axis of the field (each bin $\approx 2\%$ of the field's West-East or North-South extent) so field-scale pattern is visible without altering the underlying pixel values. Two independent measures indicate the field organizes into broad, gradually varying zones rather than a random patchwork: local variability is low (mean 5×5-cell-window standard deviation ≈ 0.032 , 90th percentile ≈ 0.045 on a 4× downsampled grid) and only about 0.8% of the field area shows local variability more than twice this average, consistent with sharp, localized transitions being confined to a very small share of the area; and spatial autocorrelation is very strong (Moran's $I \approx 0.87$ on the same downsampled grid), meaning neighboring areas have systematically similar NDRE values rather than varying at random.

At field scale, mean NDRE by thirds of the image shows a measurable north-south gradient (north third 0.441, middle third 0.409, south third 0.373 — the north measures higher than the south) and a comparatively flat west-east pattern (west third 0.395, central third 0.411, east third 0.410 — the west is marginally lower, with central and east essentially similar). The transect chart above shows finer structure within these averages:

both profiles are elevated within roughly the first 5–9% of their respective axes (reaching about 0.51 West-East near the western edge and about 0.57 North-South near the northern edge) before settling into a broad, comparatively flat plateau around 0.37–0.42 across most of the field's interior, then rising again modestly near the opposite edges. Because this elevation is concentrated at the raster's outer margins on both axes, it is consistent with edge or boundary effects (for example mixed pixels, canopy edge brightening, or partial no-data transitions) rather than an interior canopy pattern — this attribution is an interpretation, not a direct measurement.

Interpretation of Red Edge Response and Canopy Development Consistency

As a spectral index, NDRE is sensitive to red-edge reflectance associated with chlorophyll content and canopy structure; it is not a direct measurement of plant health, maturity stage, or a biological diagnosis, and this report does not treat it as one. Within that framing, the measured record supports the following observations: mean and median NDRE (0.407 / 0.401) sit within the mid-to-upper portion of the raster's measured range, and about 89.5% of valid pixels register 0.30 or higher, indicating the Red Edge response across most of the surveyed area is consistently in the moderate-to-stronger portion of the observed distribution rather than concentrated at the low end.

On spectral consistency: very strong spatial autocorrelation (Moran's $I \approx 0.87$) together with low local variability (only about 0.8% of the area showing sharply elevated local variability) indicate the canopy's Red Edge response is highly spatially coherent — it changes gradually across the field rather than in an erratic, speckled pattern. At the same time, the field is not perfectly flat in absolute NDRE level: a measurable north-south gradient places the northern portion of the field at a higher Red Edge response than the southern portion, while the west-east direction is comparatively uniform. The field can therefore be described as spectrally consistent and gradually varying, rather than uniform in an absolute sense.

These statements describe what the NDRE values and their spatial arrangement show. They do not identify a cause: NDRE alone cannot distinguish between explanations such as canopy age or maturity stage, planting density, leaf angle and canopy architecture, or shading and micro-topography, and no diagnosis of disease, nutrient deficiency, pests, or water stress is made in this report.

Uncertainty & Limitations

This is a single-date, single-raster NDRE assessment: no repeat imagery, ground reference, or other spectral/index layers (NDVI, GNDVI, OSAVI, MSAVI, chlorophyll indices, or individual spectral bands) were used to corroborate the findings, so temporal trend and independent confirmation both fall outside this report's scope. The acquisition, sensor, radiometric calibration, and processing workflow behind the NDRE raster are not documented in the QGIS project metadata available to this analysis; sensor- or processing-related artifacts (for example vignetting, mosaic seams, or calibration drift) cannot be ruled out and could contribute to some of the extreme low values noted, particularly the isolated pixels approaching NDRE -1.0.

The 54.9% valid-pixel coverage means close to half of the raster's bounding rectangle carries no data; this reflects the flight or processing extent rather than canopy condition, but it does mean the downsampled local-variability statistics are less densely sampled toward the raster's edges. Spatial variability statistics (local standard deviation, Moran's I) were computed on a 4× downsampled grid for computational tractability and are approximate rather than full-resolution measures. Finally, the descriptive NDRE bands (0.30, 0.50) used earlier are fixed cut points chosen for this report and are not calibrated to this crop's phenological stage or to any validated chlorophyll or maturity threshold.

Conclusion

On this date, the banana field's NDRE record shows a canopy with a consistently moderate-to-strong Red Edge response (mean 0.407, median 0.401), with about 90% of valid pixels at 0.30 or above and roughly 15% reaching 0.50 or higher. The field is highly spatially coherent — NDRE varies gradually and predictably across space (Moran's $I \approx 0.87$) with only about 0.8% of the area showing sharp local transitions — and its absolute level is comparatively uniform, aside from a measurable north-to-south gradient in which the northern portion of the field registers a higher Red Edge response than the southern portion. A very small number of spatially isolated extreme-low values, concentrated at the raster's outer margins, fall outside the field's main NDRE cluster and most plausibly reflect edge, shadow, or sensor artifacts rather than canopy signal, though this is an interpretation rather than a direct measurement.

Further observation is best directed at three things: confirming, on the ground or with follow-up imagery, whether the measured north-south gradient corresponds to a real difference in canopy development or maturity stage across the field; checking the raster's outer margins where the extreme-low values concentrate, to confirm whether they are data or acquisition artifacts rather than genuine canopy conditions; and treating this report's descriptive NDRE bands as a spectral reference point only, since NDRE by itself does not diagnose disease, nutrient deficiency, pest pressure, or water stress, and no such determination is made or implied here.